Nuclear physics

Teacher Name:

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(*) (Class no # First) *)

date: 8/11/2021

(*) Books name For Nucleour physics

Imp (i) S.N Ghoshal

(ii) Krane.

Nuclear Discovery & Introduction:-

In 1911 Nucleous was discovered by a newzealander Scientist → Rutherford

Some Facts about nucleous:

→ 99.9% mass of whole atom is present in nucleous

→ 100% charge of atom is present in nucleous

→ proton + Neutron common name is Nucleoun

→ Size of nucleous (radius, diameter)
= S-thing × 10^{-15} m
= neucleus distance × 10^{-15} m

1 Fermi = 10^{-15}

Now we discuss proton & Neutron

INTRODUCTION OF PROTON:

→ proton was discovered by Goldstien
→ actually discovery of proton is done by Rutherford

→ The word proton is derived by from protous which mean basic (بنیادی)

→ proton is actually nucleous of hydrogen atom

1 Proton = 1.67495×10^{-27} kg = 937 Mev

1 Neutron = 1.67565×10^{-27} kg = 938 Me

FAIMLY OF PROTON:-

(i) Faimley on basis OF Mass

(ii) Faimley on basis OF Spin

↳ on the basis of mass the proton Faimey is named as:

Hadron Faimey b/c 3 quarks

(*) proton is composed of elementry particles called quarks.

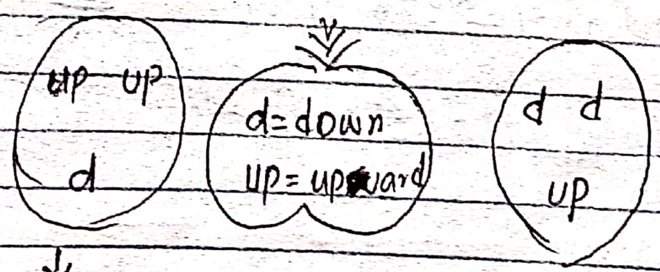
Quarks:

They are elementry unstable particles, they must combine with other quarks.

⇒ Building Block's of both Protons & neutrons

↳ Quarks posses smallest charge i.e $\frac{2}{3}e$ (or) $\frac{1}{3}e$ etc.

Proton | Neutron



Proton:

$\frac{2}{3}e+\frac{2}{3}e-\frac{1}{3}e$

$= \frac{2e+2e-1e}{3} = \frac{3}{3}e$

$= e$

Neutron:

$-\frac{1}{3}e-\frac{1}{3}e+\frac{2}{3}e$

$= \frac{-1-1+2}{3}$

$= \frac{0}{3}$

$= 0$

So charge on Neutron is ∴ 0

(ii) Now on the basis of Spin:

→ The Spin of proton is "1/2" which is the Spin of Fermions Faimly So due to 1/2 Spin it is in Femi Faimly.

→ Fermi-Dirac Statistics
here spin will be half integer

10^6 =
= Million
= mega
Symble
M

→ Bose Einstein (indian Scientist)
here Spin will be integer

(*) proton, electron & Neutron all are in Fermion Faimly b/c their Spin is 1/2

میں اپنوں سے امید لگائے تھا
مگر پھر مجھے قصہ یوسف یاد آگیا

Now we discuss another nucleon

NEUTRON:-

→ Neutron was discovered by "James chadwick"

date: (   )

one neutron posses

$1N = 1.675 \times 10^{-27} kg$

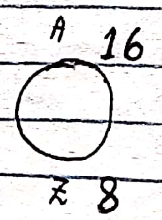
→ proton and neutron are same but little changes are present in its charge & mass, they are interconvertable to each other.

→ They don't remains in one state.

Some Facts about Neutron

(a) Neutron is made from Quarks
(b) Faimly is Hadron.
(c) Spin of neutron is "1/2" so Fermian Famly
(d) No charge (neutral) proof on P. No (3)
(e) Excess No of neutrons increases as we proceeds (ↄ to ↄ) in periodic table

✳ Natation OF Nucleons ✳



→ here atomic No i.e $Z = 8$

→ Mass no i.e $A = 16$

→ No of Neutron $= A - Z$
$= 16 - 8 = \boxed{8}$

Atomic Number: (Z)

(basically it Atomic mass)

Second name is
Charge Number (Z)

i) Cofficient in charge of nucleous when it is written in multiple of "e"
i.e

8e For oxygen
↓
Z = cofficient i.e Atomic number

ii) The number of protons presents in an atom is known as atomic number
⇒ symbole For A.No is "Z"

Mass Number: ("A")

The Sumbe of number of neutron (N) and protons (Z) inside the nucleous is known its mass number: Symbol For it is "A"
So that:

$$A = N + Z$$

⇒ Abviously "A" is an integer Just as "N" and "Z" is equal to the atomic number of the element in periodic teble.

↳ A nucleous of an atom "X" of atomic number "Z" and mass number "A" is symbolically written as:

$$\left({}^{A}_{Z}X \right)$$

For example "${}^{4}_{2}He$" denotes the nucleous of an atom i.e helium where atomic No is "2" & mass No is "4"
This is actually alpha particle.

Isotopes:-

Nuclei (Plural of nucleous) with the Same atomic No (Z) but different mass No (A) are called isotopes.

↳ Isotopes were first discovered amongst the naturally radioactive elements when J.J Thomson exploring (تلاش کرنا) the properties of positive rays by the parabola method, ~~was~~

Example:

Lithium (Z=3) has two stable isotopes "${}^{6}Li$" & "${}^{7}Li$".
کثرت / افراط / فراوانی

Abundances: Elements having more than one stable istopes in the natural state are mixture of these isotopes in fixed proportions, known as their relative abundance

${}^{6}Li$ & ${}^{7}Li$

abundence 7.4% abundence 92.6%

Isobars:-

Nuclei with sam mass no (A) but different atomic or charge No (Z) are known as Isobars.

Examples: (I) (III) (II)

$^{40}_{18}Ar$, $^{40}_{20}Ca$, $^{40}_{19}K$ (Potasium)

$^{81}_{36}Kr$ = Kripton

Isotones:

Nuclei with the same number of neutrons are known as isotones

↳ examples:

$^{3}_{1}H$, $^{4}_{2}He$, $^{5}_{3}Li$

↳ 2 ↳ 2 ↳ 2

(*) Though in nuclear physics we are concerned with the masses of the nuclei, experimental determination using mass spectrocopes yield the atomic masses.

The nuclear mass "M_{nuc}" is obtained from the atomic mass "M" by subtracting masses of "Z" orbital electrons from the latter

$$M_{nuc} = M - Z m_e$$

صبح کی نیند انسان کے ارادوں کو کمزور کرتی ہے

منزلوں کو حاصل کرنے والے
کبھی دیر تک سویا نہیں کرتے

2nd period
Date: 9/11/2021

Size of Nucleous:-

Rutherford Scattering experiment: Distance of closest approach is estimated value of Size of Nucleous:

K.E of System = P.E of system

$$\frac{1}{2} m V_\alpha^2 = \frac{2K Ze^2}{d}$$

$$d = \frac{4K Ze^2}{m V_\alpha^2}$$

As
$P.E = q_o . \Delta V \rightarrow A)$

$q_o = 2e \rightarrow (i)$

$\Delta V = V = Kq/r$

$= \frac{K . Ze}{d} \rightarrow (ii)$ put in (A)

$$P.E = \frac{2K Ze^2}{d}$$

$\Rightarrow Z = 79$ For gold

data

As $K = 9 \times 10^9 Nm^2/C^2$

$\rightarrow e = 1.6 \times 10^{-19}$

$\rightarrow m = 4 \times (1.66 \times 10^{-27} Kg)$ (mass of alpha particle)

$\rightarrow V_\alpha = 1.6 \times 10^7 m/s$

$$\boxed{d = 4.26 \times 10^{-14} m}$$

it is not actually diameter (10^{-15}) of nucleous

Now he increased Speed of alpha particle then,

$$\boxed{d = 3.2 \times 10^{-14}}$$

Now he changed Gold nucleous by copper nucleus

$$d = 1.2 \times 10^{-14}\ m$$

Gernal equation for size of nucleous

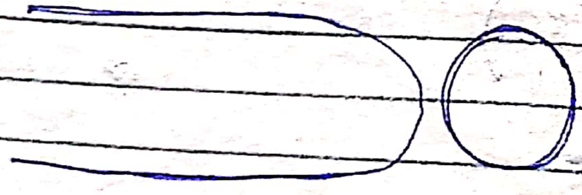
$$r = r_0 A^{1/3}$$

where

$$r_0 = 1.2 \times 10^{-15} m$$

For Hydrogen put A = 1
For uranium put A = 235 and so on.

* Diagram *



(*) 1 a.m.u = 931.5 Mev

C - carbon
Au - gold

Density of Nucleous:

⇒ let we take carbon

Mass of carbon = 12 a.m.u (atomic mass unit)

$m = 12 \times 1.66 \times 10^{-27}$ kg

$m = 1.9926 \times 10^{-26}$ kg

Now $r = ?$

As $r = r_0 A^{1/3}$

put $r_0 = 1.2 \times 10^{-15}$ m and $A = 1.9926 \times 10^{-26}$ kg

$r = 1.2 \times 10^{-15}$

$$r = 2.7473 \times 10^{-15} \text{ m}$$

Now volume = ?

As we take nucleous as a sphere (estimate)

So for sphere

$V = \frac{4}{3}\pi r^3$

put values

$$V = 8.6659 \times 10^{-44}\ m^3$$

Now density, $\rho = ?$

As $\rho = m/v$

put values

$$\rho = 2.294 \times 10^{17}\ kg/m^3$$ d

تمنا درد دل کی ہو تو کر خدمت فقیروں کی
نہیں ملتا یہ گوہر بادشاہوں کے خزینوں میں

علامہ محمد اقبال

period No# 3rd 10/11/21

3rd Period

(13)

Date: 10/11/2021

Mass defect in Nucleous:- + (331 N.G) +333

(or) (deficit)

The mass of nucleous is less than sum of masses of its nucleons. is M.D in N this defect in mass of nucleous (Δm)

$$\Delta m = \left[Z m_p + (A-Z) m_N \right] - \text{mass of nucleous}$$

(+334+NG)

BINDING ENERGY:- (Miss leading concept.)

The energy used by nucleous to bind all nucleons together is called Binding energy

→ This energy is converted from mass defect.

As $E = mc^2$

$$B.E = \Delta m c^2$$

$$B.E = \left[\left\{ Z m_p + (A-Z) m_N \right\} - \text{mass of nucleous} \right] \times c^2$$

As ~~proton~~

i) protium — its nucleous (1P) is called proton

ii) Deutron — its nucleous is Deutron (1P 1N) {it is simplest bound state}

iii) Tritium — its nucleous is Tritium

*) Binding energy of atom is also called electron effinity

→ Binding Energy per nucleous
let we take carbon, $^{16}_{8}C$

→ here it contain 16 nucleons
→ its binding energy is 30 Mev

Now

$$B.E \text{ per nucleon} = \frac{30 \text{ Mev}}{16 \text{ nucleons}}$$

$$= 1.875 \text{ Mev}$$

For

Uranium

$$B.E \text{ per nucleoun} = \frac{200 \text{ Mev}}{235}$$

0.8510 Mev

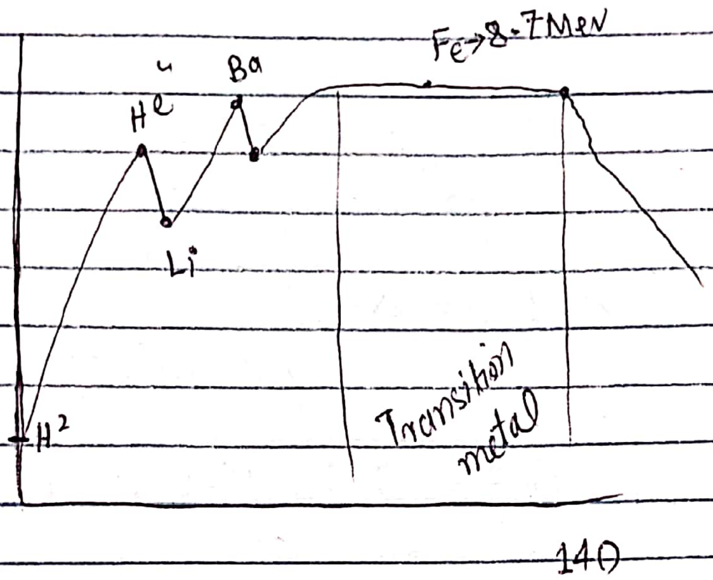
(*) larger is B.E per nucleon of a nucleous stable will be nucleous

⇒ Here we see that Binding Energy of uranium (200 Mev) is greater than the B.E of carbon (30 Mev) & But still carbon is stable from Uranium because the B.E per nucleoun of carbon is greater than the Binding Energy per nucleon of uranium atom

IF you hat physics probably you learned it from Rong Teacher

iron → 8.7 MeV it B.E
Most stable nucleous

Graph of (B.E per nucleoun Vs A)



The Middle element are Stable.

B.E = 2.22 MeV
1.11 MeV

HOME WORK

Question: Find (B.E) Binding energy per nucleon for deutron

Solution:

As $\Delta m = m_p + m_n - m_D$

put values in MeV/c^2

$\Delta m = 938.28 + 939.57 - 1875.61$

$$\boxed{\Delta m = 2.24\ MeV/c^2}$$

Now to Find B.E using formul (Eintein formula)

$B.E = mc^2$

(or)

$B.E = \Delta mc^2$

put values

$B.E = \frac{2.24 \text{ MeV}}{c^2} \times c^2$

$B.E = 2.24 \text{ MeV}$

Now we Find B.E per nucleon

So divide by "2" R.H.S

b/c of deutron

$B.E = \frac{2.24 \text{ MeV}}{2}$

$B.E = 1.12 \text{ MeV}$

Answer

paking Fraction:-

Mass defect in the nucleous per nucleon is called packing Fraction

→ here mass defect mean difference in Mass no and atomic mass unit
let M.no = 10 and a.m.U = 10.2

So Packing Fraction $10.2 - 10$
$= 0.2$

NOW ÷ by A

$P.F = \frac{0.2}{A}$

$P.F = \frac{0.2}{10} = \boxed{0.02}$

let we take a rule as
→if Atomic mass = 10
and a.m.U = 10.2

P.K Fraction $= \frac{A - amu}{A}$

⇒ $P.F = \frac{\text{Atomic mass} - \text{mass number}}{\text{mass number}}$

(*) here Δm = a.m.U − A

$P.F = \frac{\Delta m}{A}$

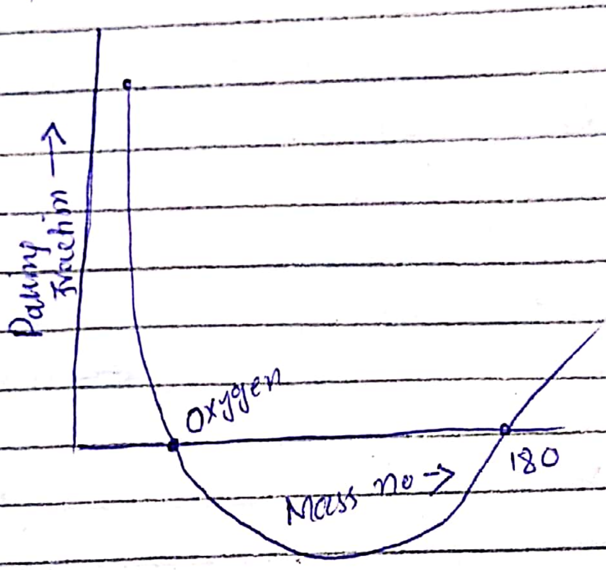
points:-

(i) Mass no (A) will be always a number/integer.

(ii) Atomic mass unit not be always integer (Atomic mass is expended in unit of a.m.u)

(iii) Paking fraction can be +ive, zero & integer

Graph



*) Every nucleous wants to minimize its packing fraction in order to get stability.

*) Oxygen posses low value of packing fraction

*) P.F and B. Energy graph is opposit.

→ $P.F \propto \frac{1}{B.E}$

*) Iron is most stable b/c its has very very less value of paking fraction.

*) as He , $\Delta m = 0.002604$ a.m.u
change to
B.E
$\Delta m = (\ ) \times 931$

B.E = 2.425 MeV

and
For Uranium
U , $\Delta m = 004396$ a.m.u

B.E = 40.~~sm~~ MeV

here He is Stable although it B.E is less than Uranium

Reason:
here He (helium) is most Stable nucleous than uranium nucleous although binding Energy of uranium is greater than helium because B.E of He is less than P.F packing fraction of Uranium
and
For ~~un~~ urinium B.E is 40.... For 235 nucleoun while in helium B.E is 2.425 MeV (less from U) but here the the no of nucleon are so much less i.e 4

→ $H_1^2 + H_1^3 \longrightarrow He_2^4 + n$ + energy

(large P.F → small P.F)

(Fussion)

$U_{92}^{235} + n_0^1 \longrightarrow K_r + Ba + 3n_0^1$ + Energy

(large P.F → small P.F)

(Fission)

5th period

16/11/2021

336 N.G

*

(A) Nuclear Angular momentum OR Nuclear Spin

* **Concept**:- In Atomic portion, we first ~~first we~~ find l, and s for an unpaired electron and by adding it we get (coupling method) L and S of atom. and here we find l, s (orbital motion and spin motion) of nucleons i.e proton and neutron and finally we get L and S of nucleous by coupling Str

Scheme.

→ Vector Atomic Model:-

(a) principle Quantum No: (n)

$n = 1, 2, 3 \cdots$

(b) Azimuthal quantum No: (l)

$l = 0 \longrightarrow n-1$

* ∫ * ∫ * ∫ * ∫ *

Thanks to Allah who enabled me to complete This "Simple Notes of Nulear Physics"

References: → Lectures of Sir Shakeel Ahmad
→ Books i) V.K Metal
ii) Ghoshal

Now For Main Topic:- (A)

→ Nuclear angular momentum or Spin is created due to motion of its nucleons to the motion of these nucleons as we gave to motions of electrons.
Finally we can find total angular momentum of nucleous by adding angular momenta of its nucleons.
It is denoted by Coupling method.

Nuclear moments:-

(i) Magnetic dipole moment.

(ii) Electric quadrupole moment

(*) Difference b/w

Magnetic momentum and Magnetic moment

Magnetic momentum: exists b/c of motion of charged perticles as well as un-charged particle

while

Magnetic moment only produce or exist b/c of motion of charged particles

(*)

First derive $\mu_0 = l \frac{e\hbar}{2m}$

From $\mu = i \cdot A$

(*) here moment is for only proton b/c it is charged particle

→ here $\frac{e\hbar}{2m}$ will be called by **nuclear Magneton** (*)

So here

m = will be mass of proton

⇒ Or **Bohr Magneton** *

while $\mu_B = 9 \ldots \times 10^{-24}$ J/Tesla

For nuclear magneton $\mu = 8.08 \times 10^{-27}$ J/Tesla

چراغِ طور بن کے سینۂ ظلمت میں جلنا ہے
شبِ تاریک کو صبحِ منور میں بدلنا ہے

(*) **1U = 931 MeV**

Subject name:-

Nuclear physics

Teacher name:-

Sir Shakeel Ahmad

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Seventh Semester (2018 — 2022)

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مردان کالج نمبر (1)

(i) Dipole
(ii) quadrupole
(iii) law of cosine

6th Period

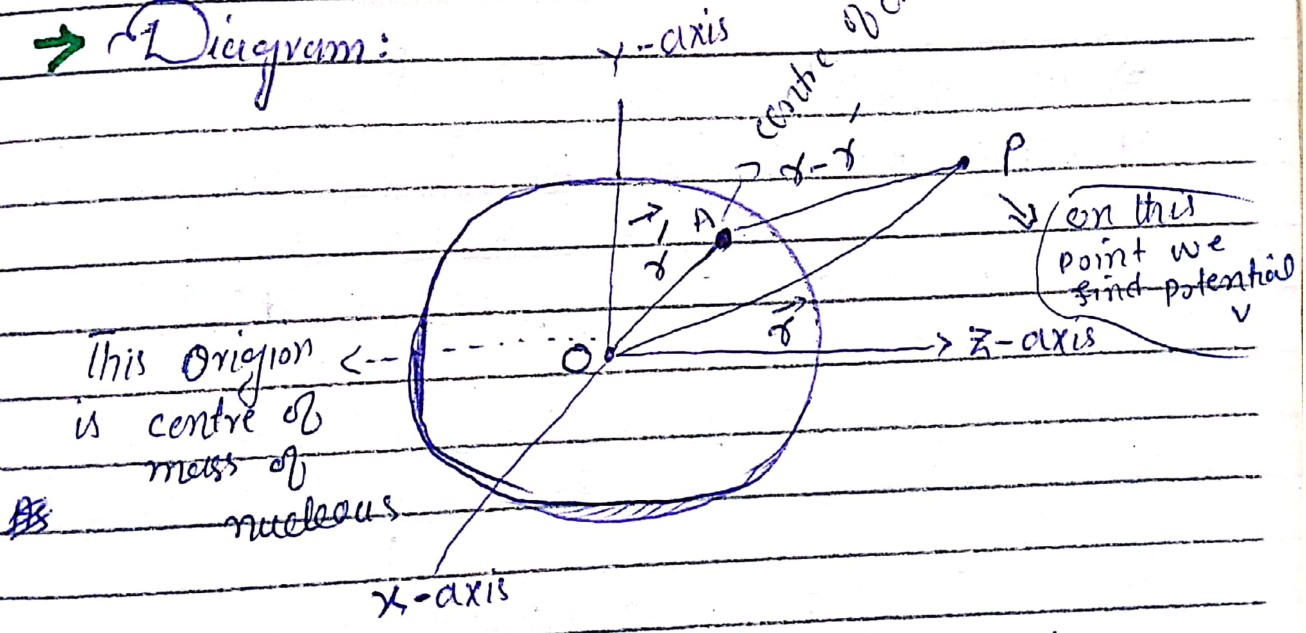
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Nuclear moments:

(i) Magnetic dipol moment:
(ii) Magnetic quadrupl moment:

Electric qudrupl moment exist in those nuclei whose centre of mass and centre of charge doesn't concide.
⇒ If centre of mass and centre of charge concides then nucleous will be completely Sphere and qudruple moment does not ~~cand~~ exist.

→ Diagram:



consider triangle "OAP" using law of cosine

→ as $V = \frac{Kq}{r}$ P. For point charge

$$V = \frac{Kq}{|\vec{r}-\vec{r}'|}$$

*W

$$V_{(P)} = \frac{1}{4\pi\varepsilon_0} \times \frac{e}{(r^2 + r'^2 - 2rr'\cos\theta)^{1/2}}$$

(or) ~~÷ by r^2 b/s~~ ↓ * here take r^2 common

$$V_{(P)} = \frac{e}{4\pi\varepsilon_0}\left(\frac{1}{r^2\left(1 + \frac{r'^2}{r^2} - 2\frac{r'}{r}\cos\theta\right)}\right)^{+1/2}$$

$$V_{(P)} = \frac{e}{4\pi\varepsilon_0 r}\left(1 + \left(\frac{r'}{r}\right)^2 - 2\left(\frac{r'}{r}\right)\cos\theta\right)^{-1/2}$$

⇒ as $r' <<< r$ so $\left(\frac{r'}{r}\right)^2 \approx 0$

and using binomial formula

$$(a+b)^n = a^n + n a^{n-1} b^1 + \frac{n(n-1)}{2!} a^{n-2} b^2 + \frac{n(n-1)(n-2)}{3!} a^{n-3} b^3 + \dots$$

$$V_{(P)} = \frac{e}{4\pi\varepsilon_0 r}\left(1 - 2\left(\frac{r'}{r}\right)\cos\theta\right)^{-1/2}$$

using B. Formula

*W/ $$V_{(P)} = \frac{e}{4\pi\varepsilon_0 r}\left[1 + \frac{r'}{r}\cos\theta + \left(\frac{r'}{r}\right)^2\left(\frac{3}{2}\cos^2\theta - \frac{1}{2}\right) + \left(\frac{r'}{r}\right)^3\left(\frac{5}{2}\cos^3\theta - \frac{3}{2}\cos\theta\right)\right]$$

Rough work for

(*)

$$V_{(P)} = \frac{e}{4\pi\epsilon_0 r} + \frac{e r'}{4\pi\epsilon_0 r^2}(\cos\theta) + \frac{e r'^2}{4\pi\epsilon_0 r^3}\left(\tfrac{3}{2}\cos^2\theta - \tfrac{1}{2}\right) + \cdots$$

points:-

On R.H.S

i) Ist term is contribution to potential b/c of Single charge ($V = \frac{kq}{r}$)

ii) 2nd For dipole

iii) ~~For~~ 3rd For quadrupale.

while "$e r' \cos\theta$" is electric dipole moment

and $e r'^2 \left(\tfrac{3}{2}\cos^2\theta - \tfrac{1}{2}\right)$

is electric quadrpule moment.

→ Symbole for electric Q. moment is "Q"

→ unit its unit is "Cm^2" (SI) (C → coloumb)

and normally its unit is

$e \times 10^{-24}\ cm^2$

(*) where 10^{-24} is called barn

another unit for length

Some quadrupule moment

$H_1^2 = +0.0028$ e barn

$^{133}C_s$ (sezium) $= -0.003$ e barn

$Q > 0$ (positive Q. moment)

shape

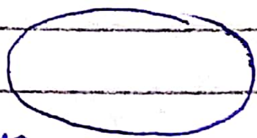


name prolate

and

$Q < 0$

shape

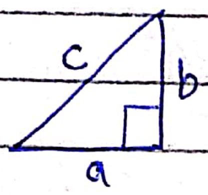


name :- oblate

Related Work

For law of cosine, m :

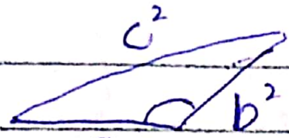
-> one is right angle triangle



so here

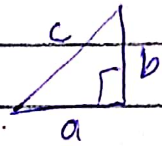
$c^2 = a^2 + b^2$

-> one is a triangle of the type



here the consider angle i.e "120°"
So here we don't use $c^2 = a^2 + b^2$
here we use law of Cosine i.e

$$c^2 = a^2 + b^2 - 2ab\cos\theta$$

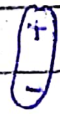
if this angle is 90° i.e 

then

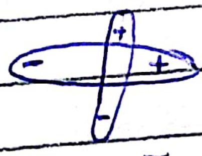
$$c^2 = a^2 + b^2 - 2ab\cos 90^\circ$$

$$\boxed{c^2 = a^2 + b^2}$$

*) c will must opposit to considered angle.

=> Dipole mean having two poles -> 

while
quadrupole means having Four pole i.e



-> Centre of mass: That point on which the whole mass of the body is concentrated
-> centre of charge: whole charge ....
-> centre of gravity: whole gravity .....

Q.M → concept

7th period
22/11/2021

Wave Mechanical

properties of Nucleous:

(i) parity (ii) Statistics

here we discuss only parity now

Parity:

parity operator → 2nd name inversion operator

→ If parity operator is applied on a wave function $\psi(r) \rightarrow \psi(-r)$

i.e

$$P\psi(x, y, z) = \psi(-x, -y, -z)$$

Now apply parity again

$$P^2\psi(x, y, z) = P\psi(-x, -y, -z)$$

$$P^2\psi(x, y, z) = \psi(x, y, z)$$

$$P^2\psi = \psi 1$$

$$P^2 = 1$$

$$\boxed{P = \pm 1}$$

(*) electron charge i.e $e = 1.6 \times 10^{-27}$ C is minimum charge in the world ∴ it is called elementry charge

$P\psi(x,y,z) = P\psi(-x,-y,-z)$ | córdinates

$P = +1$ even parity

$P = -1$ odd parity

→ For even parity:

$$\psi(-x,-y,-z) = \psi(x,y,z)$$

→ For odd parity:

$$\psi(-x,-y,-z) = -\psi(x,y,z)$$

→ Combinally:

$$P = \pm 1$$

$$\psi(-x,-y,-z) = \pm\psi(x,y,z)$$

(*) parity is purly quantumicanical concept
→ Analgue i.e (classical Example) difficult.

(*) charge always exists on mass,
xx → ~~every charge can't exists without mass~~
but

→ Any mass can exists without ~~mo~~ charge but any type of charge can't exists without mass

Now parity OF Hydrogen like system:

$P = (-1)^l$ → l = orbital q.no

→ For different particles parity will be must different.

* For proton and neutron
$p = +1$

For a system of particles parity of a system is equal to the product of parities of its constituent particles.

⇒ A system having even number of particles will have odd parity then particles will have even parity

↳ here even number mean: 2, 4, 6, 8...
↳ & odd parity mean = -1

let For 4

So $-1 \times -1 \times -1 \times -1 = +1$

W- boson

→ A system having odd number of odd parity particles (particles having odd parity) ~~will have odd parity~~
→ So parity of whole system will be odd
i.e -1, -1, -1 = -1

* Parity always will be conserved

→ parity for nucleous if it contain only protons and neutron = +1

if other particles comes in nucleous like β-particles, mison etc then parity of nucleous will be not +1

Except for weak interaction:

parity of a system will be always conserved.

→ let we consider an excited nucleous

odd [nucleous] excited (parent nucleous) → odd [Daughter nucleous] + even α-particles

odd x even = odd

(*) It is convencient that: parity of parent nucleous is equal to the product of parity of daughter nucleous & the parity of some particles like α-particles etc

→ This is not followed in weak interaction

particles	parity:
Mesons (π^+ & π^-)	even, odd
Baryons (protons, neutrons)	even
Anti Baryons	odd
Lepton (electron) →	even
photons, gluons →	odd

Faimly (ies) OF Particles:

→ On the basis oF Mass There are three Families

i) Hadrons ii) Leptons

iii) photons

$E=hf$ or $E=h\nu$

its rest mass Energy $= 0$

→ photon can't be ÷ mass

* Hadron & lepton has rest mass

↳ Lepton and photon are not more divisible

→ Leptons examples

(i) electron (ii) neutrino

neutrino mass is very less than electrons ( ) and posses no charge.

↳ **Hadron:** (hador mean large)

→ They are composite mean made from elementry particles

→ elementry particles of hadrons are quark, which doesn't more divisibles

→ Quark can never exist on its own. mean it will must combine with other particles

Types OF Hadron

(i) Baryons: it consists of 3-quarks

→ Don't contain anti quarks

examples:

protons, neutrons.

(ii) Mesons:

it contain 2 quarks

→ one quark + one anti quarks

examples:

Pi-mesons, K-mesons, U-mesons

quark:- are smaller particle

→ it posses strong nuclear force

For Memorizing charge consider strange & bottom as $-$(down quark) = $+\frac{1}{3}e$

Quark	symbol	charge	Spin
(i) up	u	$+\frac{2}{3}e$	$\frac{1}{2}$
(ii) down	d	$-\frac{1}{3}e$	$\frac{1}{2}$
(iii) Strange	s	$+\frac{1}{3}e$	$\frac{1}{2}$
(iv) charm	c	$+\frac{2}{3}e$	$\frac{1}{2}$
(v) Top	t	$+\frac{2}{3}e$	$\frac{1}{2}$
(vi) bottom	b	$+\frac{1}{3}e$	$\frac{1}{2}$

(*) ~~for charge~~

proton: Find charge on proton?

Ans As proton cotain 3 quarks

(u u d) $\Rightarrow +\frac{2e}{3} + \frac{2e}{3} - \frac{1e}{3}$

$= \frac{2e + 2e - 1e}{3} \Rightarrow \frac{3e}{3}$

$= \boxed{e}$ So charge on proto[n]

Neutron:

Question: Why neutrons are chargeless particles?

Ans: Similarly ~~pr~~ Neutron is composed from:

(d d u) $= \frac{-1e}{3} - \frac{1e}{3} + \frac{2e}{3}$

$= \frac{-2e + 2e}{3} = \frac{0}{3}$

$= 0$ So Neutron is chargeless particle.

Nuclear Spin:

→ Nucleer Spin mean total angular momentum of nucleus i.e of proton and Neutron
→ Symbole "J" or "I" while for electron P_j

Definition:-

The vector sum of all of angular momenta of all of its nucleons is called T.A.M Total angular momentum of nucleous

→ They are combined by
→ L-S coupling
→ J-J coupling

Table

→ Odd A nuclei will have Spin half integer (Fermion)

→ even A nuclei will have Spin either zero or Full integer. (Bosons)

* STATISTICS *

more detail see (350) TSP(Book)

Suppose a pinch ( ) of matter contains a very large number of atoms or molecules i.e $N_a = 6 \times 10^{26}$ per mole (Avagadro's No) So For this it is impossible to apply the ordinary laws of mechanics to a pysical system containing large No of particles particularly that of electrons. Such problems are however, successfully solved by:

Statistical Mechanics:

There are three statistics depending upon three different kinds of particles.

(i) Maxwell-Boltzman's Statistics:

This is applicable to the identical, distinuishable particles of any spin.
For example: gas Molecules.

(ii) Bose-Einstein Statistics:

This is applicable to the identical, & indistinguishable particles of zero or integral spin, these particles are called Bosons. the example of bosons are i) helium atom at low temperature ii) photons

Fermi- Dirac Statistics:

This is applicable to identical, indistinguishable particles of half integral spin. These particles obey Pauli exclusion principle and are called Femions. example election, proton & N

↳ Th classical statistic successfully explained the phenomenon like temperature, pressure & energy etc. but faild to explain black body radiation, specific heat at low tempture For this new approach i.e Bose Einstein & Fermi-Dirac introduced.

Bose Einstein:

Those particles which follow this statistic are called Bosons.

examples of Bosons:

(i) Graviton
(ii) Pi - meson
(iii) photons

properties:

(i) Spin value of Boson → whole integer
(ii) Don't follow pauli-exclusion principle.
(iii) Wave function of system of Bosons is symmetric
i.e

$$\psi(x_1, x_2, x_3) = \psi(x_2, x_1, x_3)$$
$$= \psi(x_3, x_1, x_2)$$

Fermi Dirac Statistics:

Those particles which follow this statistics are known as Fermions
examples of Fermions:
(i) electrons
(ii) protons
(iii) Neutrons

→ properties:
i) Spin will be half integer
ii) Follow pauli exclusion principle
iii) wave function of Fermion is anti-symetric
i.e

$$\psi(x_1, x_2) = -\psi(x_2, x_1)$$

* * * * *

Shortly particles distribution:

i) **Fermions** → Leptons (light weight) i.e electrons
→ Baryons (Protons & Neutro

→ its all spin = 1/2

ii) **Bosons:** → photons (rest mass = zero)
→ Mesons (Gravitons, photo pi-meson etc)

9th Period
date: 29/11/2021

ISOBARS:

Nuclei whose mass number "A" is same but different charge No (Z)

Examples: $^{40}_{18}Ar$, $^{40}_{19}K$, $^{40}_{20}Ca$, ~~$_{18}$~~

OR

USMAN
Ali Shah

Second Def:

The nucleids (plural of nucleous) having same mass number "A" but different charge No (Z) are known as Isobars

⇒ The chemical and physical properties of isobars are different.

Example: $^{15}_{7}N$, $^{15}_{8}O$ (or) $^{3}_{1}H$, $^{3}_{2}He$

Mirror Nuclei :-

(Mirror pair)

Two nuclei will be mirror nuclei of each other if proton number(Z) of one nucleous is equal to neutron number of other nuclei and vice versa.

Example:

(i)

$^{3}_{1}H$, $^{3}_{2}H$

(*) Z = Nutron No (or) Shorty whose A are same

Z=1 N=2

Z=2 N=1

(ii)

$^{14}_{6}C$ $^{14}_{8}O$

Z=6 N=8

Z=8 N=6

*) Mirror nuclei posses same spin and same parity

Imp

Nature of Nuclear Forces:

The Forces known in the begining of twentieth century was gravitational force and Electromagnetic Force (colomb) which was not account for the stability of Nucleous. As the proton posses the positive charge, while the neutron posses no charge, So the E.force b/w two protons will be repulsive force means the nucleous will be break is pieces and thus it cannot account for the binding of the Nucleous. Similarly the gravitional force is also not valid for the nucleous binding b/c the gravitational force is for the Macro bodies such as astronomical objects.

The Small size of the nucleous (few Fermi (10^{-15})) and its great Stability Shows the forces operating among the nucleons (P+N) are Short-range Force, this new force called Nucleour Force

Some important Charateristics of Nuclear force are:

(i) Charge Independent:

The nuclear for is charge indepent i.e the force b/w P-P, N-P - N-N are Same, This is clear from the formation of Mirror Nuclei

(ii) Nuclear Forces are very Stronger.

Nuclear Forces are 137 times Stronger from electromagnetic force and 10^{38} times from G.Force

(iii) Saturated in nature:

The range of nuclear forces ~~is~~ are limited. Saturation of N.Force implies that their interaction is only with the nearest neighbours. The effect of Saturation property of N.Force is that the binding energy is proportion to "A"

(iv) Repulsive at very Short distance:

Repulsive Nuclear forces are repulsive at ≈ 0.5 fm if it was not so. the nucleons inside the nucleus would collapse the size of nuclear force range.

(v) Non-central:

The ~~Electromagnetic~~ gravitational and Electrostatic forces are central mean acting along the line joing the centres of two bodies while the act both along the line and other directions.

* For More explaination see page No # (25) of BOOK (V.K Mital)

* Nuclear Forces *

(i) Gravitational Force
(ii) Electromagnetic Force

i) ii) > present on microscopic and macroscopic level.

(iii) Strong nuclear Force
(iv) Weak nuclear Force

(*) ABDUSALAM
→ pakistani Doctor

he gived a theory in which he had combined the (iii) and (iv) No Forces and called them:
by Electro weak Force

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Origin OF Forces:

→ Gravitational Force origin is mass.

→ Electromagnetic Force origin is charge (Not exact origin)

→ Strong nuclear and weak nuclear Force (or) Nuclear Force origin is ~~Beg~~ Being Neutron

Range OF Forces:

→ Gravitational and Electromagnetic Force are long range Forces

⇒ Long range Force:: That Force which decreases very slowly by increasing distance b/w two bodies

Scanned with CamScanner

(*) $F_e = 10^{38} F_G$ so Fe very strong

(47) electromagnetic Force (F_G → Gravitational Force)

(1) → Strong and weak Nuclear Forces are Short range Force

(*) 1 Femto meter → Attraction
0.8 Femto meter → repulsive
2.5 Femto meter → Zero

(2) ↳ Strong nuclear Force is attaractive while weak nucler force is repulsive

→ range of S.N.F is large
range of W.N.F is Zero (0.8 Femto meter)

(*) Nuclear Forces:

This Force depends on Some basic points

(3) (i) Mass and charge independent Forces
(4) (ii) Spin dependent Force & Momentum dependent i.e motion dependent
→ if two particle in nucleous passes ∥ Spin So its N.F will be Same and will be diff For anti parallel

(5) (iii) very strong Force (1 femto m)

→ N.F is 137 times stronger than Electromagnetic F
(i) " 10^{40} time " Gravitational Force

(b) → Gravitational and Electric Forces are central Forces i.e that line which join the centre of two bodies.

But

Nuclear Forces acts along the line as well as in other directions.

Mediating Bosons:

(i) Gravitional Force:-

Hypothetical Mediating Bosons for G.F are Gravitons

(ii) electromagnetic Force:

virtual photons

(iii) Strong nuclear Force:

Pi mesons (Pions)

(Yukawa Theory)

(iv) Weak nuclear Force:

W and Z bosons

Extra

(Four forces in Nature)

i) Strong Nuclear Force:

-> its ~~range~~ Strenth is 10^1
-> Theory related to this Force is Chromodynamics
-> Mediator for this force Gluons

ii) Electromagnetic Force:

-> its Strength is 10^{-2}
-> Theory related to this force is Electrodynamics.
-> Mediator -> photons

iii) Weak Nuclear force:

↳ Strength = 10^{-13}
↳ Theory = Flavourdynamics
↳ Mediator = W & Z Bosons

iv) Gravitational force:

↳ Strength = 10^{-42}
↳ Theory = Geometrodynamics
↳ Mediator = Graviton (hypothetical)

10th Period
date: 30/11/2021



Yukawa Theory OF Nuclear Forces: (1935)

: (Mesons Theory)

Statement:

The interaction between nucleer nucleons is mediated by exchange of quantum (called Pi-meson) between nucleons. In other words π mesons are emitted by one nucleon and absorbed by other. This exchange maintains bond b/w nucleons.

→ It is just like the electromagnetic force carried by photons.

pi-Meson properties:

⇒ Types OF PiMeson:

(i) π^- (negative π Meson

it occur b/c of interaction of Neutron and proton

$$\boxed{1\ \frac{MeV}{c^2} = 1.78 \times 10^{-30}\ kg}$$

1U = 931.5

(ii) π^+

interaction Proton, Neutron

(iii) π^0 (neutral)

interaction n-n, P-P

→ Mass of meson 300 × Me

⇒ $1\ MeV/c^2 = 1.78 \times 10^{-30}\ kg$

$M_\pi(+iv) = 139.57\ MeV/c^2$

M_π in kg $= 2.48 \times 10^{-28}\ kg$

$M_{\pi^0} = 134.97\ MeV/c^2$

$m = E/c^2$

$m = MeV/c^2$

$E = mc^2$

$m = \frac{E}{c^2} = \frac{MeV}{c^2}$

MeV → Million electron volt

⇒ $M_\pi = 300 \times Me$

Charged on charged Pi-meson (pions) → e

$\pi^+ = u\bar{d} = +\frac{2}{3}e + \frac{1}{3}e = e$

$\pi^- = d\bar{u} = -\frac{1}{3}e - \frac{2}{3}e = \frac{\cancel{3}}{\cancel{3}} = -e$

$\pi^0 = u\bar{u}$ or $d\bar{d} = 0$

u = upward $\frac{2}{3}e$

d = down $-\frac{1}{3}e$

anti $\bar{d} = +\frac{1}{3}e$

⇒ Pimesons are basically Boson

Spin: Pi-Mesons have Spin "0" or full integer

Parity:- Pi-Mesons parity is −1

(ii) Neutro-Proton interaction:

$$n \longrightarrow P + \bar{\pi}$$

$$P + \bar{\pi} \longrightarrow \text{neutron}$$

To explain neutron proton interaction a neutron decays by emission of proton and ($\bar{\pi}$) negative pion as shown in the above reaction: and this negative pion ($\bar{\pi}$) is absorbed by another proton ($\bar{\pi} + P \rightarrow n$) resulting in the formation of "n"

(*) In the case of single nucleon the pions are constantly emitted and absorbed by the same nucleon, i.e a nucleon is surrounded by a cloud of pions.

*)

(ii) PROTON - NEUTRON INTERACTION:

$$P \longrightarrow n + \pi^{+}$$

$$n + \pi^{+} \longrightarrow \text{Proton}$$

Similarly to explain proton Neutron interaction, a proton decay into neutron with the emission of positive pion (π^{+}) which is immediatly absorbed by the other neutron resulting in the formation of neutron again as shown in above Reaction

* *

گورنمنٹ کالج مردان 1

(iii) PROTON - PROTON interaction:

$$P \rightarrow \ddot{P}' + \pi^{0} \qquad \pi^{0} \text{ (neutral)}$$

$$\ddot{P}'' + \pi^{0} \rightarrow P'''$$

In this interaction a proton decays to another proton by emission of neutral (π^{0}) pion which is absorbed by "p" and convert to p''

Neutron-Neutron interaction:

$n \rightarrow n' + \pi^0$

$n'' + \pi^0 \rightarrow n'''$

here a neutron decays to $n' + \pi^0$ and when this π^0 combine with the present neutron it convert to another neutron i.e n'''

→ Zero Mass mediating bosons → long range

example : Gravitons.

→ Non-zero mass mediating boson → Short range

→ In these transformation mass is not conserved and uncertainity of mass of π meson exist

From uncertainty principle

i) $\Delta p \times \Delta x \approx h$ or $\hbar$

ii) $\Delta E \times \Delta t \approx h$ or $\hbar$

here we use $\Delta E \times \Delta t \approx \hbar \rightarrow (A)$

as $E = m_\pi c^2$ put in (A)

so

$$m_\pi c^2 \times \Delta t \approx h$$

$$c \times \Delta t \approx \frac{\hbar}{m_\pi c}$$

$$\frac{1.2\times10^{-13}\,cm}{100} = 1.2\times10^{-15}\,m$$

$$c\times\Delta t \approx \frac{h}{m_\pi c} = 1.2\times10^{-13}\,cm$$

$$= 1.2\times10^{-15}\,m$$

↓

Same as radius of nucleous

which is range of this force.

اپنی غلطی کا اعتراف
کرلینا کسی مسئلہ کے حل کی
طرف پہلا کامیاب قدم ہے

مولانا وحید الدین خان

11th Period
date :- 7/12/21

Isotropic Spin or Iso-Spin:-

⇒ Owner → Hysenberg

⇒ It is a Spect Fictious (فرضی) Spin Quantum number (which is a vector quantity) give to Sub-atomic particles or nuclei) which help us to deal nucleons as electrons.

→ All particles inside nucleous are two different states of a Single particle called nucleon.

Symbole:
Its symbole is "t" or "I"

Value of isospin:
Value for isospin is related with number of up & down quarks in a particle.

Now For PROTON::
It is given as

iso spin up → $t = +1/2$

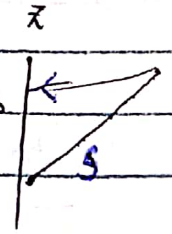
Neutron:
$t = -1/2$

⇒ As classically $P_t = t\hbar$
&
Q. mechanically $P_t = \sqrt{t(t+1)}\ \hbar$

Now Fitious projection::

here we introduce an fitious co-ordinate system i.e

As



1, 2, 3 co-ordinate axes

For 1 → x-axis
2 → y-axis
3 → z-axis

1, 2, 3, cordinate system is also an virtual c.system

Now For any nucleous t_3 :-

$$t_3 = \frac{1}{2}(Z - N)$$

Z → Proton number
N → Neutron number

let take H - atom
so here (P = 1 , N = 0)

$$t_3 = \frac{1}{2}(1$$

$$\boxed{t_3 = \frac{1}{2}}$$

(γ) Isospin → up For proton & down = Neutron

OR// another Formula

$$t_3 = \frac{1}{2}(n_u - n_d)$$

For H - atom

n_u = up quarks

$$t_3 = \frac{1}{2}(2 - 1)$$

$$\boxed{t_3 = \frac{1}{2}}$$

In Hydrogen there is only one proton For which we know that

1 proton = contain 3 quarks

(up up dw)

↳ Two Nucleon system:-

Cases:

(i) 2P 0N

(ii) 1P 1N

(iii) 0P 2N

For case (i)

as $Z = 2$, $N = 0$

use any Formula

$$t_3 = \frac{1}{2}(2 - 0)$$

$$\boxed{t_3 = 1}$$

(ii)

OP 2N

$Z = 0$ & $N = 2$

$$t_3 = \frac{1}{2}(0 - 2)$$

$$\boxed{t_3 = -1}$$

(iii)

$P = 1$, $N = 1$

$$t_3 = \frac{1}{2}(1 - 1)$$

$$\boxed{t_3 = 0}$$

(H/W)

12th period
8/12/2021

Spin Dependence of Nuclear Forces

Low energy neutron proton Scattering crossection ⇒

Theoritically value = σ (sigma) = 3 barn

Experimentally

σ = 20.38 barn

H/W
barn unit of area = $10^{-24} m^2$

Difference in values b/c : ie b/w theoritical & Experimental
E.P wigner said that n-p interaction depends on Spin orientations.
So due to this dependence values are different.

Now as
For proton s = 1/2 ⇒ spin = s
neutron s = 1/2

parallel Spin = 1

Statistical weight or relative probability = 2S + 1
= 2(1) + 1
= 3 → Triplet Spin scattering

proton = $\frac{1}{2}$
neutron = $-\frac{1}{2}$

Anti-parallel $S = 0$

Statistical weight = $2S+1$

= 1 → Singlet Scattering

Triplet Scattering:

That scattering which is from interaction of nucleons (n-p) having parallel spin.

→ It s. value = 3/4

(*) Total crossection → σ

$$\sigma = \frac{3}{4}\sigma_T + \frac{1}{4}\sigma_s$$

as area of sphere
$a = 4\pi r^2$

$\sigma_s = 4\pi a_s^2$
(~~triplet~~)
singlet

$\sigma_t = 4\pi a_t^2$
(triplet)
(~~singlet~~)

$a_t = r$
= 4.8 femptometer

$20 = \frac{3}{4} \times 3 + \frac{1}{4} + \delta_s$

$\boxed{\delta_s = 71 \text{ barn}}$

Cases:-

(i) $a_t = +4.8$ Femto meter

if a_t is +ive then triplet state will form (parall) it will form bound state

(ii) $a_s = -4.8$

→ not form bound state

state → singlet state

Next Chapter # (3)

Period no# (13)
Date: 13/12/2021

C# name:

Nuclear Models

Alot of Nuclear models are present but here we will discuss some Models:

(i), (ii) ~~(i) (ii)~~ Liquid drop Model, shell model
(iii), (iv) ~~(iii) (iv)~~ Nilson Model, Fermi gas Model
(v), (vi) ~~(v) (vi)~~ Bohr Motelson model, collective model etc

Liquid ~~drop~~ and collective Model

⇒ (i) & (vi) No: models are on the basis of very strong interaction

⇒ (ii) & (iv) are on the basis of weak interaction.

↓ Shell Model & Fermi gas Model

Liquid Drop Model:

In 1935 Weizsaker proposed that nucleous is like a liquid drop.

First we discuss Similarities b/w liquid drop & Nucleous

Liquid drop	Nucleous
(a) Intermoleculer Forces in drop	(a) Nuclear Force b/w nucleons
(b) Density of droplet is independent of size of droplet	(b) Similarly density of nucleous doesn't depend on size.
(c) Emission of particles from a droplet vapours etc	(c) Emission of particles from nucleous. α, β rays etc
(d) condensation/absorbtion of water vapours into a droplet	(d) Absorbtion of proton or neutron into nucleous
(e) inside a droplet the internal energy is present i.e thermal K.E	(e) Internal energy inside nucleous.

*) On the basis of above Similirities Weizsaker proposed that nucleous is just like a liquid drop.

*) Neutron star is most denser particle of world
↳ common nucleous density is = Neutron star

* Main assumption OF Liquid Drop Model *

(a) A Nucleous is Just like a liquid drop
(b) Nucleous consists of incompressible matter
(c) Nuclear Forces are independent for every nucleous
(d) Nuclear Forces are Saturates
(e) Nucleous is Sperically symetric in equilibrium position

(*) The main work of this Model is
Semi-~~mass~~ emperical mass Formula

Semi-emperical mass Formula:

Mass of nucleous (M) =
$Zm_p + (A-Z)m - B.E$

here we will discuss mass defect and Binding energy in detail

=> Binding energy itself is made from others energy
i.e actually

$(B.E) B = B_1 + B_2 + B_3 + B_4 + B_5$

(*) here Mass & energy are same b/c both are inter-convertble to each other.

Now we discuss all B.Energies one by one

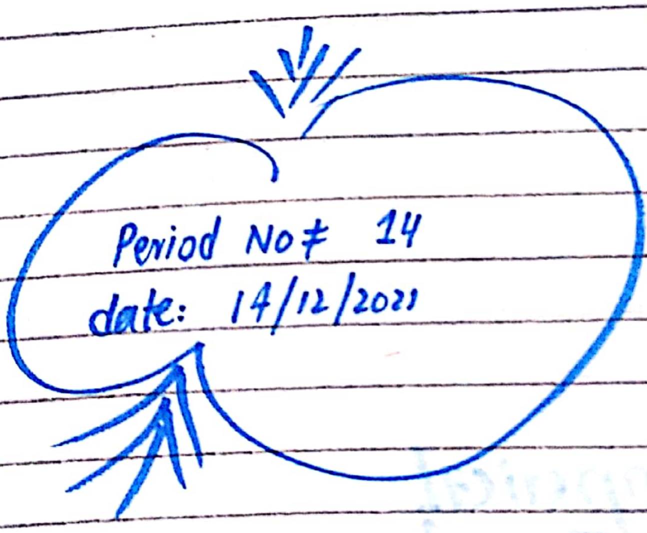
(i) B_1 (volume energy term):

This B.E is created because of strong nuclear force b/w nucleons.
It is attractive B.E & its equation is

$$B_1 = +a_v A$$

where "a_v" is constt called en

(*) $B_1 \propto A$ → mass No



$B_1 \propto$ Volume

$B_1 \propto \frac{4}{3}\pi r^3$

$B_1 \propto \frac{4}{3}\pi r_0^3 (A$

$B = $ constt A

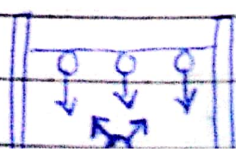
$$B_1 = +a_v A$$

(ii) Surface Energy term (B_2):

This is basically a correction in "B_1"

here discuss same phenomenon like surface tension as shown





This term is correction in volume energy term and is due to fact that surface nucleons are not actually attracted by that much force as nucleons inside nucleous

$B_2 \propto$ Surface area of nucleous

$B_2 \propto (4\pi r^2)$

$B_2 = ?$ {numerical value}

$B_2 \propto (4\pi (r_0 A^{1/3})^2)$

$B_2 \propto 4\pi r_0^2 A^{2/3}$

$$B_2 = -a_s A^{2/3}$$

here the -ive sign show decrease in energy i.e from B1

iii) Coloumbic Energy Term (B_3):

It is because of positive charge repulsion inside nucleous

$$B_3 = a_c \frac{Z(Z-1)}{A^{1/3}}$$

it is also decrease in Binding Energy

This term is base on no of proton & Neutron are equal or not

(iv) Assymetry Energy term (B_4):

This term is related to number of protons & neutrons being equal it is decrease in Binding Energy when "N" and "Z" are not equal

$$B_4 \propto \frac{(N-Z)^2}{A}$$

$$B_4 = -a_a \frac{(N-Z)^2}{A} \text{ or } \frac{(A-2Z)^2}{A}$$

a_a → Assymetry

Uranium

$^{235}_{92}U$ — 235 → A (mass no), 92 → Z (atomic no)

235-92 = 143

N-Z = 143

92 – 143

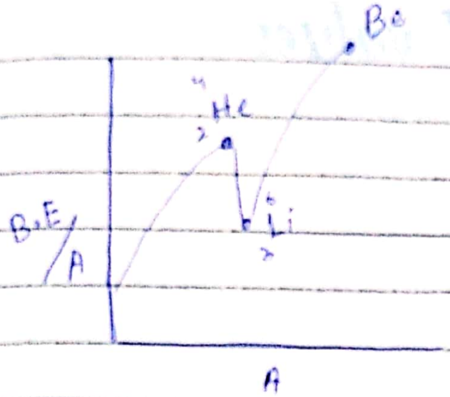
This difference is very greater So ∴ it is unstable

(v) pairing Energy term (B_5):

Table

Z	N	No of stable nuclei
Even	Even	165
Even	odd	55
odd	Even	50
odd	odd	5

${}^4_2He$ No. = A - Z
No of neutrons = 2



here B.E For He is greater than ${}_3Li$

b/c He is stable where no of Neutron & proton are equal

This (B_5) term aries b/c of proton & neutrons being even. (Pairing)

$$B_5 = \pm a_p A^{-3/4}$$

putting these all values in given B.E equation

i.e

$$B = B_1 + B_2 + B_3 + B_4 + B_5$$

$$B = a_v A - a_s A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_a \frac{(N-Z)^2}{A} \pm a_p A^{-3/4}$$

$(A-2Z)^2$

Now put values in mass equation

$$M = Zm_p + (A-Z)m_N - a_v A + a_s A^{2/3} + a_c \frac{Z(Z-1)}{A^{1/3}} + a_a \frac{(N-Z)^2}{A} \pm a_p A^{-3/4}$$

b

Now constt values:

~~$a_p = 1$~~

$a_v = 15.5$ Mev
$a_s = 16.5$ Mev
$a_c = 0.7$ Mev
$a_a = 23$ Mev
$a_p = \pm 11.2$ Mev

(or)

$a_p = $ 34 Mev → even even nuclei
0 → odd A
-34 Mev → odd odd nuclei

Combine example:

Term	Ca^{40}_{20}	Sn^{120}_{50}	U^{238}_{92}
Volume	+620	+1860	+3689
Surface	-196	-409	-973 (→ -645)
Coloumb	-80	-358	~~-282~~
Assymtry	0	-77	-282
Pairing	+2	+1	+0.6
Resultant B.E	346	1017	1789.6
B.E/A	8.65	8.48	7.52

Mass OF The MOST Stable Isobars:

$M(Z,A) = aA + bZ + cZ^2 \pm \delta$

See book (51) for This Topic

خواہشیں بادشاہوں کو غلام بنا لیتی ہیں

مگر صبر غلاموں کو بادشاہ بنا دیتا ہے

*** * * *

Assignment :-

Mass of the Most Stable Isobar:-

Isobars → These are nuclides that have Same "mass Number "A"

e.g $^{40}_{18}Ar$, $^{40}_{18}K$ (Potasium), $^{40}_{20}Ca$

The Semi-emperical mass formula can predict the atomic Number "Z" of most Stable isobar for given mass No "A"

As $M(Z.A) = aA + bZ + cZ + cZ^2 + \delta$

(A)

where

$$a = M_n - \left[a_v - a_a - \frac{a_s}{A^{1/3}}\right]$$

$$b = -4a_a - (M_n - M_p)$$

$$c = \left(4a_a/_A + \frac{a_c}{A^{1/3}}\right)$$

and $\delta = \mp a_p A^{-3/4}$

Taking derivation of eq (A) w.r.t "Z" and put = 0
i.e

(A) ⇒ $\partial M/_{\partial Z} = \partial/_{\partial Z}\left(aA + bZ + cZ^2 + \delta\right) = 0$

$$\partial M/_{\partial Z} = b + 2Zc = 0$$

or

$$b + 2Zc = 0$$

$$2cZ = -b$$

$$\therefore \boxed{Z = -b/_{2c}} \quad \text{or} \quad \boxed{Z_0 = -b/_{2c}}$$

where "Z_0" is the atomic Number of Most Stable isotope for given "A"
Substituting the values of "b" and "c"

$$\boxed{Z_0 = \frac{-4a_a - (M_n - M_p)}{2\left[\frac{4a_a}{A} + a_c/_{A^{1/3}}\right]}}$$

On putting values in this equation we can fin ~~atomic~~ Mass of Most Stable isobar.

Achivements & Failere of Liquid Drop MOdel:

See book page No (52)

AChievements of L.D.M:

Following are the some achievements of this Model

(i) This Model predicts the atomic masses and binding energeries of various nuclei.

(ii) It predicts the emission of "α" and "β" particles in radioactivity.

(iii) The theory of Compound nucleus, which is based on this Model explain the basic features of this fission process.

* * * * * *

Failures of Liquid Drop Model:-

(i) This Model fail to explain the extra stability of certain nuclei where the no: of protons or neutrons in the nucleus are 2, 8, 20, 28, 50, 82 or 126 (Magic Numbers)

(ii) This Model fails to explain the measured Magnetic moments of many nulei

(iii) It could not explain spin of nuclei

(iv) The excited states in most nuclei are also not explained by this Model

(v) The agreement of semi-emperical mass formula with experimentally observed masses and binding energies is poor for lighter nuclei compared to the heavy ones.

2nd MODEL

Period No# 15
date: 21/12/21

Shell Model:-

here two main points was;

(a) What type of potential require to oscillates nucleons in shells
↳ oscillate mean circulate

(b) The nucleous is very small so when the nucleons circulates in shell then they will be accident with each other?

Basic of this Model:

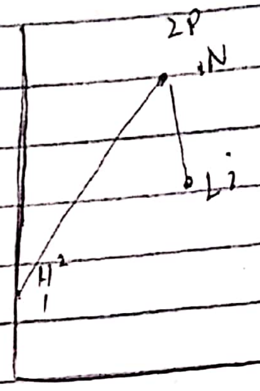
(Magic Numbers)

↳ 2, 8, 20, 28, 50, 82, 126

= No = 7

Evidence of Magic Numbers:

(i) ↳ Binding Energy per nucleou



here magic no of helium is two so its B.E Per nucleons is high.

(iii) Number of stable Isotopes:

As

(a) $_{19}K = 3$ (No of stable isotope) $_{21}Si = 1$ (Sizium)

$_{20}Ca = 6$

here Calcium has more Stable isotopes b/c it posses ~~stable~~ magic no (20)

(b) $_{49}In = 2$ $_{50}Sn = 10$ $_{51}Sb = 2$

↓

M. no

(iii) Number of Stable Isotones:

N	No of stable isoton
19	0
20	5 → (*)
21	1
49	1
50	6 (*)
51	1

(iv) Most abundant element or nuclei: (دستیاب)

(a) Oxygen $^{16}_{8}O$ = $N = Z = 8$

(b) Calcium Ca^{40}_{20} $N = 20$

(c) Sn (tin) S^{118}_{50} $N = 50$

here N (Number) are present i.e M.No

(v) Spontaneous neutrons emitters:

$^{17}_{8}O_{9}$ $^{81}_{36}Kr_{51}$ (krypton) $^{137}_{54}Xe_{83}$ (xenon)

posses M.g no: i.e 17 − 9 = 8

$81 - 51 = 30$

(vi) Neutron absorbtion Cross Section (σ):

Neutron (N)	absorbtion co-efficient (σ)
19 (barn)	2
20 (barn)	0.41
21 (barn)	12
~~18~~ 49 (b)	19
50 (b)	0.65
51 (b)	6.4

↳ here all those having Magic Number don't posses the absorbtion co-efficient like inert gases.

ہم اپنی غلطیوں سے زیادہ
اپنی شرافت کی قیمت ادا
کرتے ہیں

Yoloka Begani Match

A1 HHH.....

Period No# 16
date: 22/12/21

* potentials *

nucleous posses potential b/c of which nucleons are bound in nucleous

(i) Square well potential:

here we consider the nucleous as a well having;

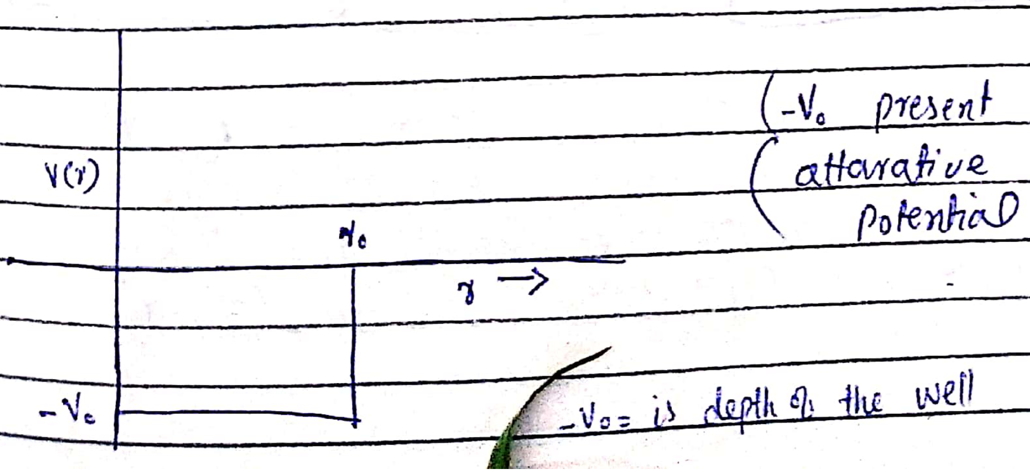
(i) $V(r) = -V_o$ $\quad r < r_o$
↓
inside nucleous

(ii) $V(r) = 0$ $\quad$ when $r > r_o$

(outside nucleous)

where "r_o" is radius of nucleous

& "r" distance when we go out from nucleous



⇒ If we apply Schrodinger equation on these boundry conditions the following level (or) shell will be arise:

1s
1p
1d
2s
1f
2p
1g
2d
1h
3s
2f
1i
3p
2g

and so on, where s, p, d, f, g, h, i ... etc stand for usual spectroscopic notation $l = 0, 1, 2, 3, 4, 5, 6 \dots$ respectively

s = 2
p = 6
d = 10
f = 14
g = 18
h = 22
i = 26
(generally)

level	No: of nucleons	M: No:
1s	2	2 (*)
1p	6	8 (*)
1d	10	18
2s	2	20 (*)
1f	14	34
2p	6	40
1g	18	58
2d	10	68
1h	22	90
3s	2	92
2f	14	106
1i	26	132
3p	6	138

The No:s shows in coloum (3) of above table are not observed magic Nos. The sequence of levels for square well potential is shown in (Fig *)

method for Memorizing the levels

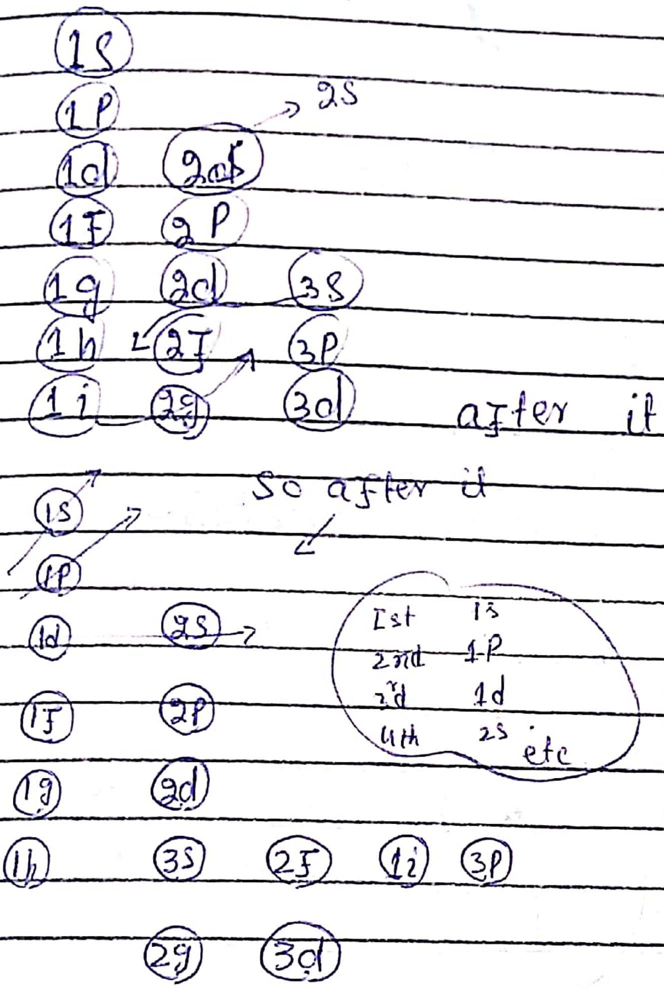


Fig: *

3P	6	138
1i	26	132
2f	14	106
3s	2	92
1h	22	90
2d	10	68
1g	18	58
2P	6	40
1f	14	34
2s	2	20
1d	10	18
1P	6	8
1s	2	2

(*) this potential explain only some magic no so therefor now we introduce another potential.

(*) 28, 50, 82 & 126 are not explained here

(ii) Harmonic Oscillator potential:

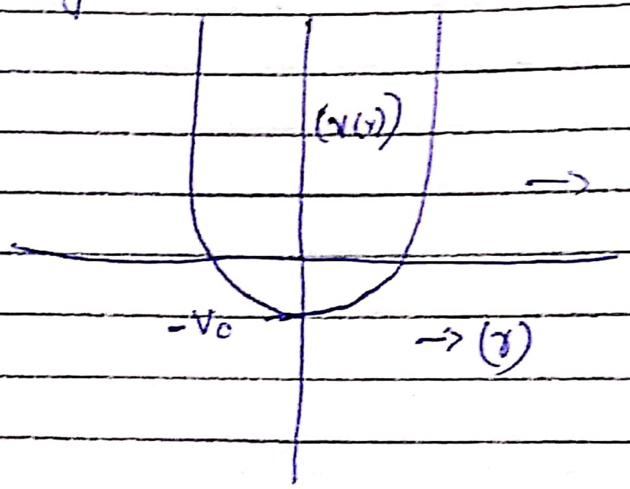
As its equation is

$$V(r) = -V_0 + \frac{1}{2} K r^2$$

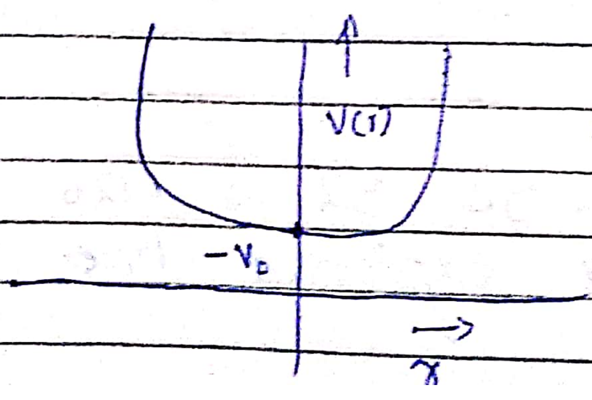
(P.E = $\frac{1}{2} K x^2$

here $+\frac{1}{2} K x^2$ is an addition term so put in Schrodinger equation and levels will be obtain.

diagram of Harmonic O.P



Rong



Correct

levels	No of nucleons	Magic NO
1S	2	2
1P	6	8
2s 1d	2+10=12	20
2P 1f	6+14=20	40
3s 2d 1g	2+10+18=30	70
3P 2f 1h	6+14+22=42	112
1i 2g 3d		

Same method for Memorizing

1S			
1P			
1d	2S		
1f	2P		
1g	2d	3S	
1h	2g	3P	
1i	2h	3d	4S

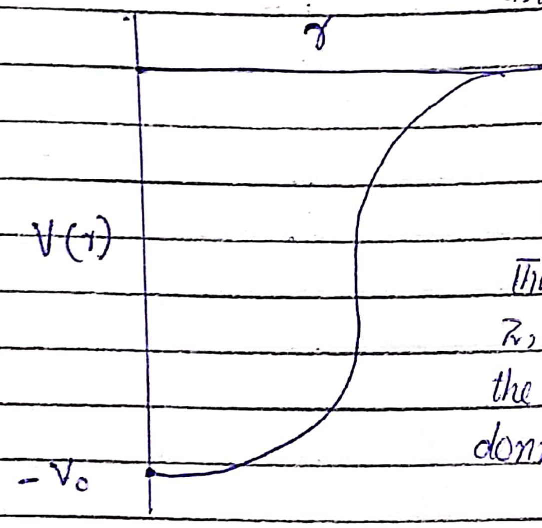
while writing of this sequence leave two space as blank in each step (writing of each column)

This potential and the Square well potential provide two contrasting (فرق/مقابلہ) view points. The Square well has infinite sharp edges. The harmonic oscillator potential diminishes (کم کرنا) steadily (مضبوطی سے) یا (باقاعدہ) at the edges

Period No# 17
date: 23/12/21

(iii) Wood Saxon potential:

graph:



→ This potential was a compromis b/w the First and 2nd one.

→ when S.E was Salved For this So it predicted 2, 8, 20, 40, 58, 92, 112,
Thus we again get 2, 8, 20 M: Numbers but the higher Magic numbers donn't emerge From the calculation

where

$$V(r) = \frac{-V_0}{1 + e^{R-r/d}}$$

$d = 0.524$ Fm

r = Distance of nucleon From centre of nucleous

R = radius of nucleous
↳ mean nucleous distance

Using this potential some magic number was explained but all M.Nos was not explained.

After this

M.G Mayer 1949 (USA)
and O. Haxel and H-E Suess (Germany)

he tried to explaine all the magic numbers so for this:
he used

~~Additional~~
⇒ Addition of Spin-orbit coupling

as

$P_l = \sqrt{l(l+1)} \cdot \hbar$

$P_s = \sqrt{s(s+1)} \cdot \hbar$

as

$s = +\frac{1}{2}, -\frac{1}{2}$

$\vec{j} = \vec{l} + \vec{s}$

$l = 0, 1, 2, 3 \dots$
↓ ↓ ↓
s p d
↓
Sub shell

s = spin

Now for $l = 0$ i.e s (sub shell) i.e $S = 0$

So $J = ?$

As $J = l \pm s$

$J = 0 + \frac{1}{2} = \frac{1}{2}$ & $J = 0 - \frac{1}{2} = -\frac{1}{2}$ ✗ not allowed

J = Spin of nucleus
S = Spin of nucleons

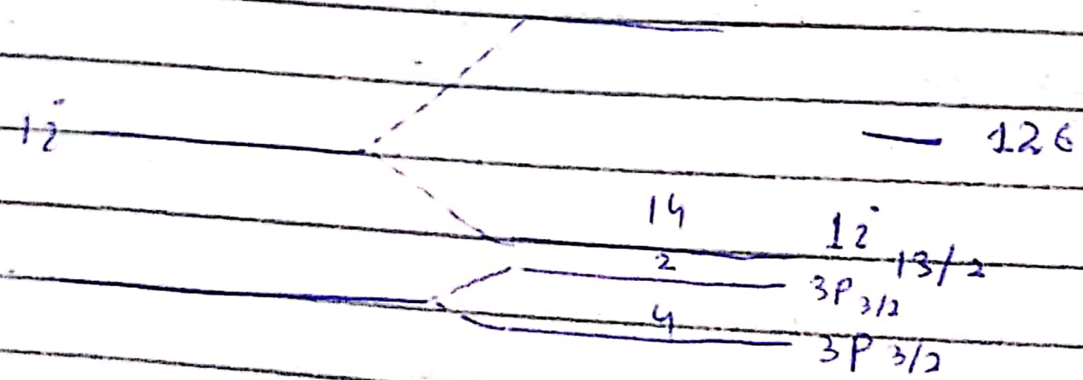
For $l = 1$

$J = l \pm S$

$J = 1 + \frac{1}{2} = \frac{3}{2}$ $\qquad$ $J = 1 - \frac{1}{2} = \frac{1}{2}$

Spliting will be in 2

Diagram From book See in Screen Shots



علامہ محمد اقبال

Nucleous Spin will be get
From unpaired nucleons always

(*) This model great achivement
is
it explain Spin of nucleous

example:
we take a nuclei i.e $C^{13}_{6\ 7}$

and Nitrogen $N^{13}_{7\ 6}$

which are mirror nuclei

$C_{6}\ 7 \rightarrow$ neutrons
↓
protons

$$(1S_{1/2})^{2}\ (1P_{3/2})^{4}\ (1P_{1/2})^{1}$$

↓
unpaired
whose $J = 1/2$

which is Spin of
whole nucleous.

Now take Oxygen

$$^{17}_{8}O_{9}$$

$$(1S_{1/2})^2 \; (1P_{3/2})^4 \; (1P_{1/2})^2 \; (1d_{5/2})^1$$

$$\downarrow$$

$$J = 5/2$$

So here nucleous spin is $5/2$

تاریخ

تاریخ اگر ڈھونڈے گی ثانیٔ محمدؐ

ثانی تو بڑی چیز ہے سایہ نہ ملے گا

Class No # 18
17/1/2022

Fermi Gas Model:

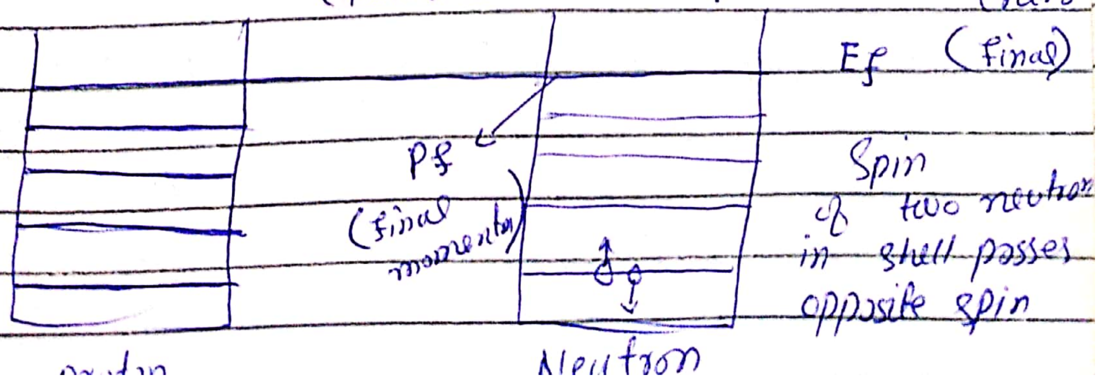
→ Fermi gas: that gas (Particles) which follow Fermi Dirac statistics
⇒ A gas (or) combination of non-interacting Fermions
↳ It is a quantumechanical version of ideal gas.

examples:
→ Neutrons in neutron stars
→ protons and neutrons inside the nucleus.

* FERMI GAS MODEL *

Nucleus has degenerate gas of proton and neutron → Fermions (Proton + Neutron) which fill up Fermi levels according to pauli exclusion principle.

→ Wells for Protons and Neutrons (potential energy well)



assumptions:

(i) Temperature very low i.e 0K

(ii) $N = Z = A/2$

(iii) There is no repulsion b/w protons.

(iv) Finite no of Fermi level

↳ Energy and Number density etc of nucleons is found by Fermi Dirac Statistics (In Fermi level)

→ here we only study neutron.

→ In these levels the last level i.e E_f, From here lowest Binding energy start.

Number of neutrons states per unit momentum interval

$$\frac{dN}{dp} = 8\pi P^2 V / (2\pi\hbar)^3$$

V = volume of potential well i.e volume of nucleous

$$\to N = \frac{2 \times \frac{4}{3}\pi P^3}{\hbar^3 \left(\frac{2\pi}{L}\right)^3}$$

$$N = \frac{8\pi P^3 V}{3(2\pi\hbar)^3}$$

$dN = ?$

$$\frac{dN}{dp} = \frac{8\pi P^2 V}{(2\pi\hbar)^3}$$

For Final

$$\frac{dN}{dp} = \frac{8\pi \overset{V}{\wedge} P_f^2}{(2\pi\hbar)^3}$$

$$\frac{dN}{dp} = \frac{V P_f^2}{\pi^2 \hbar^3}$$

As

$$K.E = P^2/2m$$

For Final

M= mass of neutron

$$E_f = P_f^2/2M$$

$$P_f = (2M \times E_f)^{1/2} \longrightarrow (*)$$

Now for whole well integral of (*) from $0 \longrightarrow P_f$

which will give No of neutrons upto P_f neutrons

i.e $$N = \int_0^{P_f} \frac{dN}{dp} \times dp$$

So

$$N = \int_0^{P_F} \frac{V \cdot P_F^2}{\pi^2 \hbar^3} \, dp$$

$$N = \frac{V}{\pi^2 \hbar^3} \int_0^{P_F} p^2 \, dp$$

$$N = \frac{V}{\pi^2 \hbar^3} \left. p^3/3 \right|_0^{P_F}$$

$$N = \frac{V}{\pi^2 \hbar^3} \frac{P_F^3}{3} - \frac{0}{3}$$

$$\boxed{N = \frac{V P_F^3}{3\pi^2 \hbar^3}}$$

$P_F = ?$

$$P_F^3 = \frac{3\pi \hbar^3}{V} \cdot N$$

$$P_F = \left(\frac{3\pi \hbar^3}{V} \cdot N \right)^{1/3}$$

$$P_F = \frac{(3)^{1/3} (\pi)^{1/3} \cdot (\hbar^3)^{1/3} \cdot (N)^{1/3}}{(V)^{1/3}}$$

$$\boxed{P_F = (3\pi)^{1/3} \left(N/V \right)^{1/3}}$$

as Final energy is given as:

$$E_F = \frac{P_F^2}{2M}$$

here put P_F value:

$$E_F = \frac{(3\pi^2)^{2/3} (N/V)^{2/3} \hbar^2}{2M}$$

In this equation V= volume of nucleus
$V = 4/3 \pi r^3$

→ $r = r_0 A^{1/3}$
→ M= mass of neutron
→ $N = Z = A/2$

putting values

$$E_F = 30 \text{ MeV}$$

⇒ Well depth:
30 + least B.E of least bound neutron

so from experiments = 8

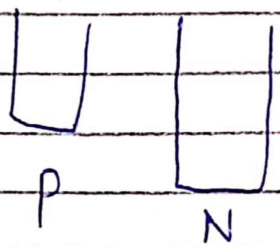
Well depth = 38 MeV

For Proton

(7) i) the well depth is lower from neutron well

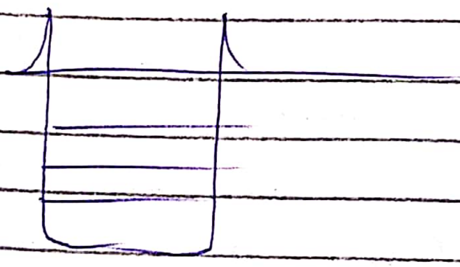
Reason:

proton always less from Neutron



ii)

its shap possess tunneling



"انسان سخت مزاج اُس
وقت بنتا ہے
جب اُس کی نرم مزاجی کا
بہت سارے لوگ فائدہ اٹھا
چکے ہوتے ہیں"

Madam currie → birth place
polland

(95) (85)

Clloe (Collective Model) ⇒ assignment

New ch

* Radiative decay *

Natural Radioactivity:

→ discovered by Baequeral in 1897 accidently

→ This process occure at those atoms whose atomic No (z) > (greater than) 82

Later. Rutherford and Madium polly said that all those atoms show radioactivity whose atomic No is greater than 82

examples: i) Uranium $z = 92$
ii) polonium $z = (\ )$ discovered by Madam currie
iii) proctinium $z (\ )$
iv) radon $z (\ )$ (v) Radium $z (\ )$

⇒ Emitting radiations:
α, β γ
(alpha) (Beta) (gama)

→ Radio isotopes:
changing no of neutrons artificially in neuclesus
↳ Then emission occurs from such neuclesus.

? Aplastic Animea → name of diseases from which Madam currie died

→ In periodic table last elements are unstable b/c its B.E per nucleons is insufficient for their nuclei

⇒ Alpha (α): Helium nuclei

$$_{2}^{4}He \quad (4 \rightarrow A,\ Z \leftarrow 2)$$

→ It is a packet of 4 neutron and 2 proton

↳ $$_{Z}^{A}X \rightarrow {}_{Z-2}^{A-4}X + {}_{2}^{4}He$$

↓ alpha desintegration Energy

⇒ charge on alpha particles:

⇒ Mass of alpha particles:

↳ Beta particle: (β) → electron

→ Beta particle emitt from nucleous and nucleous doesnt contain electrons.

⇒ From nucleous two types electron emitts

$\overset{0}{\underset{-1}{\beta}}$ ↓ electron

$\overset{0}{\underset{+1}{\beta}}$ positron

$Z = -1$ or 1
$A = 0$

(*) -ive "β" emission:
here "Z" increases by "1" and "A" remains unchanged

$$^{A}_{Z}X \rightarrow {}^{A}_{Z+1}X + {}^{0}_{-1}\beta + \bar{\nu} \text{ (anti neutrino)}$$

(*) positive "β" emission:
here "Z" decreases by 1 and A → unchanged

$$^{A}_{Z}X \rightarrow {}^{A}_{Z}X + {}^{0}_{+1}\beta + \nu \text{ (neutrino)}$$

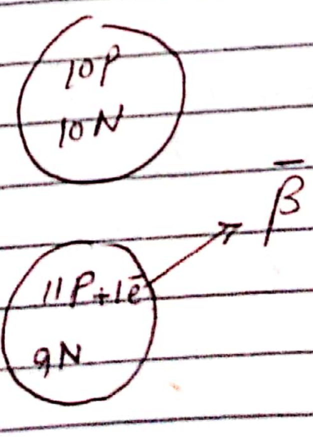
⇒ how electron produce in nucleous and Z increase by "1" & A → unchanged

Ans: -ve -β particle:

$$\overset{0}{\text{neutron}} \rightarrow \overset{+e}{\text{proton}} + \overset{-e}{\text{electron}} + \bar{\nu}$$

(electron → β-particle)

let $Z = 10$
$A = 20$



→ +Ve β-emission:

proton → neutron + $\overset{+}{\text{electron}}$ + ν
(positron (+β) over electron; neutron under ν)

(*) Gama (γ) emission:

symbole γ^{0}_{0} → its energy can find by $E = Fh$

→ No mass and no charge
→ $Z = 0$ and $A = 0$
→ its penetrating power is high from all
→ γ emission occur's from excited nucleous.
→ Can't be detected by E.F or B M.F
Nucleous emission:
i) By emitting α or β
ii) By gaining energy from external

(*) From de-excition of electron it emitt photons (i.e x-ray photon)

From nucleous deexitation " " γ (gama) rays whose frequency is very high

→ Nucleous when emitt gama rays so there will be no change in A and Z of nucleous.

Nuclear decay modes

- α emission
- β emission
- γ emission

i) α emission only one method of its emission.

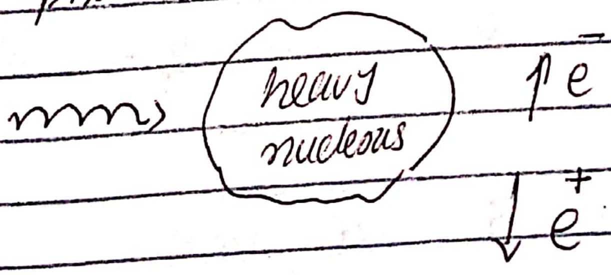
ii) β emission: (a) +ive β emission
(b) -ve β emission
(c) electron capture

(c) very low possibility but occur.
here the nucleous attracted the electrons towards itsel. b/c of which "Z" decreases by "1" and A → remains unchanged

(iii) γ emission
(a) γ decay (b) Internal conversion
(c) Internal conversion conversion (pair production)

(b) here the nucleous use its energy for ejection of electrons from shells

(c) here γ rays photon use for pair production i-e



Half life: ($T_{1/2}$)

That time in which Neulei remains of its half.

let Suppose

50,000 radium

25,000 radium

So during this the time interval are called half life.

→ radio active decay is an exponential process

(*) exponential mean: dependence on intial nos.

↳ its equation contain "e" must

let Intially numbe of nuclei is N_0

Number of nuclei after 1 half life

$$1\ T_{1/2} \rightarrow \frac{1}{2} N_0$$

→ after 2 half life

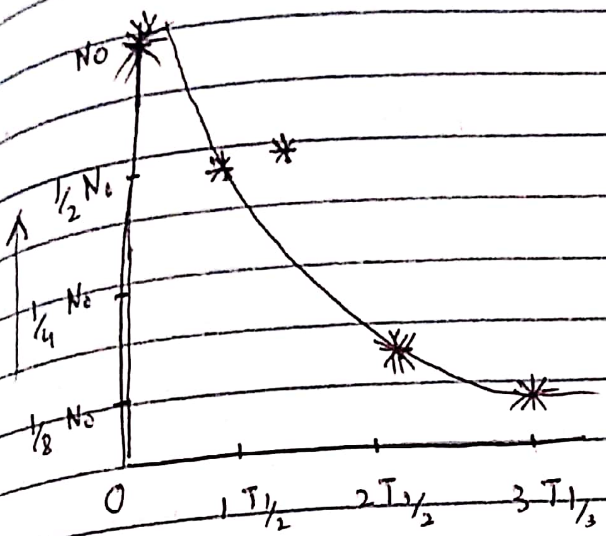
$$2\ T_{1/2} \rightarrow \frac{1}{2} \cdot \frac{1}{2} N_0 = \left(\frac{1}{2}\right)^2 N_0$$

↓ No of nuclei left

→ after 3 half life

$$3\ T_{1/2} \rightarrow \frac{1}{2} \cdot \frac{1}{2} \cdot \frac{1}{2} N_0 = \left(\frac{1}{2}\right)^3 N_0$$

* Graph *



Class no # 20
date : 19/1/2022

Radioactive decay law:

if N → no of initially nuclei
ΔN → decrease in no of nuclei
and Δt → time taken
then:

$$\Delta N \propto N \Delta t$$

$$\Delta N = -\lambda N \Delta t$$

-ive sign shows a decrease in number.

$$\boxed{\frac{dN}{dt} = -\lambda N}$$ } -ve Sign show decrease in number

→ where "λ" is not wavelength but it is decay const dependce on nature of material

→ $\frac{dN}{dt}$ = activity, no of nuclei ~~depend~~ decrease per Send

its unit (SI) is Bacqurrel symbol (Bq)

↳ If a one nucleous desingtegrate (ختم) in one Second. this → decay nucleous

another unit:

is curie (Ci)

$$\boxed{1\ Ci = 3.7 \times 10^{10}\ Bq}$$

⇒ as $\frac{dN}{dt} = -\lambda N$

$$\frac{dN}{N} = -\lambda\, dt$$

Using integration

$$\boxed{N = N_0 e^{-\lambda t}} \rightarrow (*)$$

R. work

$\int \frac{dN}{N} = -\lambda \int dt$

$\ln N = -\lambda t + c$

(or) $N = e^{-\lambda t} \cdot C$ (ln × ln = + ×)

For C = ?

$N_0 = e^{-\lambda(0)} + c$

$\boxed{c = N_0 e^{\lambda t}}$

Now

$N_0 \rightarrow$ no of nuclei intially

$N \rightarrow$ no of nuclei left after time "t"

put $t = 0$ in (*)

$$N = N_0 e^{-\lambda(0)}$$

So

$$\boxed{N = N_0}$$

its mean that at intially i.e time $t=0$ the nuclei are totaly present.

⇒ Now after half life i.e $T_{1/2}$

So

$$N = \frac{1}{2} N_0$$

as $N = N_0 e^{-\lambda t}$

put values

$$\frac{1}{2} \cancel{N_0} = \cancel{N_0} e^{-\lambda T_{1/2}}$$

$\ln 1 = 0$

$\ln e = 1$

$$\frac{1}{2} = e^{-\lambda T_{1/2}}$$

$$\ln 1 - \ln 2 = -\lambda T_{1/2} \ln e$$

$e^{\lambda t} \quad c$
$e \quad + e$

$$\cancel{-} \ln 2 = \cancel{-} \lambda T_{1/2}$$

$$T_{1/2} = \frac{\ln 2}{\lambda}$$ or $$\lambda = \frac{\ln 2}{T}$$

its unit is 1/sec

$T_{1/2}$ for ^{14}C → 5700 year

For Ra 1600 yrs

Rn →

HOME WORK

Mean life or Average life:

Soddy → 1904

do → yourself

As from equation "$N = N_0 e^{-\lambda t}$" we have see that infinite time is required for the complete disappearance of the radiactive material (remember & example: i.e Measure length of class (sir))

In order to remove this ambiguity Soddy in 1904 introduced the concept of Mean or Average life.

(105) Date: 25/1/2022

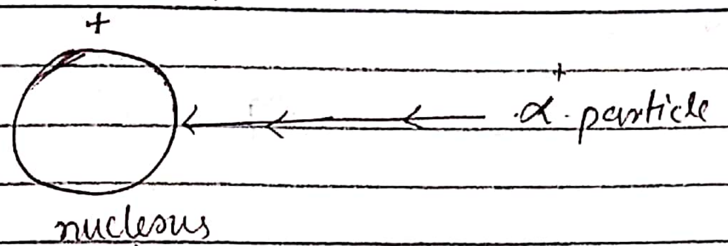
25 Mev less than and cross

↳ 14 Mev

~~11 Mev~~ least

Theory of Alpha decay:

(Gamow theory)
(Russian Scientist.)



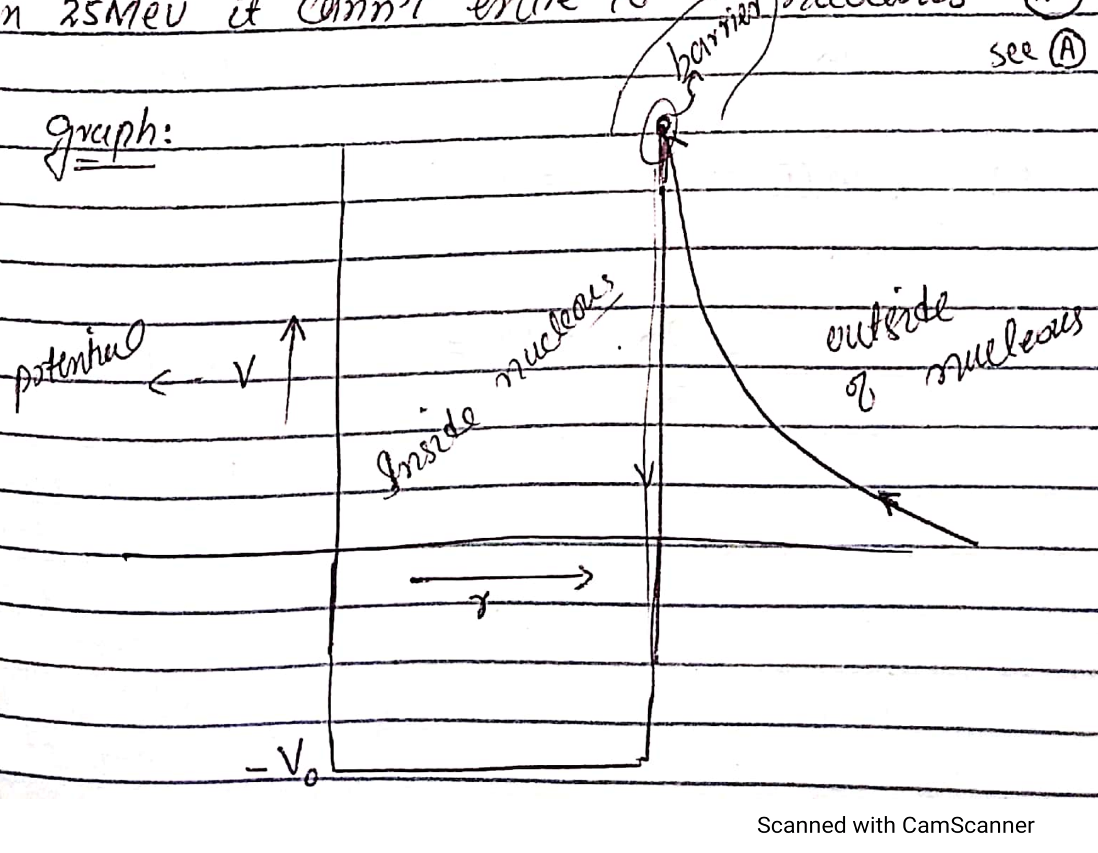
Theory: (generally): When the α-particles become near to nucleous so columbic repulsive Force exists, when we increase the velocity of alpha particle more and more so they entre to nucleous, where nucleour Force (attractive) already exists.

So From this discussion we get the result that:

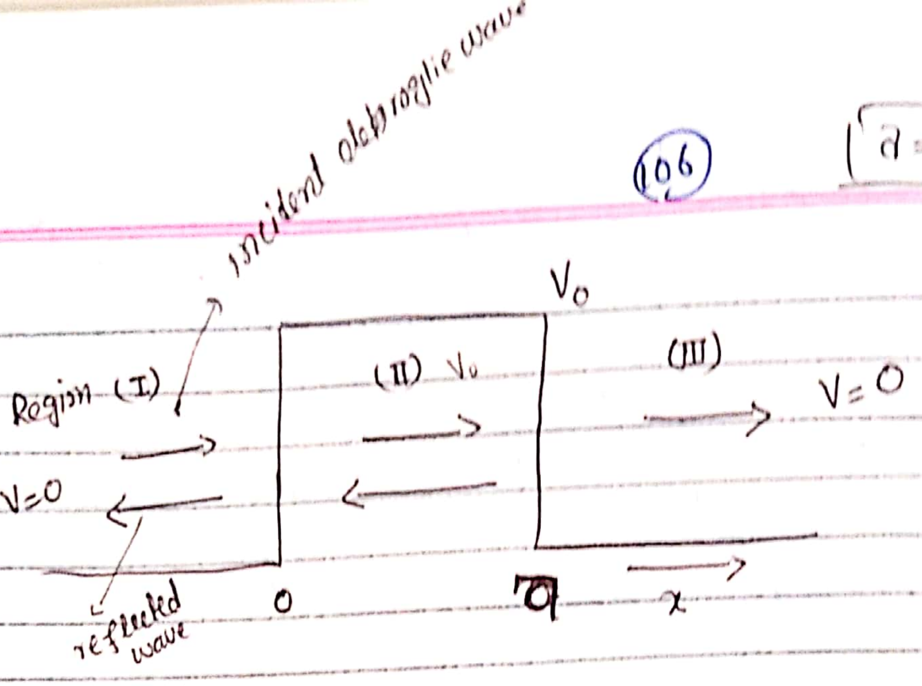
both entreing and outgoing From nucleous are difficult.

↳ when the α particle (He_2^4) posses less Energy than 25Mev it cann't entre to nucleous. (11) see (A)

graph:



$\overline{a = a}$



(I) $V(x) = 0$ For $x < 0$

(II) $V(x) = V_0$ For $0 \leq x \leq a$

(III) $V(x) = 0$ For $x > a$

One dimension Schrodinger wave equation

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}(E - V)\psi = 0$$

↳ apply this eqtn for all regions

For Region (I)(III) as $V = 0$
so

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}(E)\psi = 0 \quad \text{Region (I, III)}$$

here i) α particle
and ii) nucleus
So two body system
use reduce mass ~~defect~~ concept
i.e $\mu = mM/m+M$

For "m":

here we deal two body system as one body system i.e reduce mass concept

$$m = \frac{m_\alpha M_d}{m_\alpha + M_d}$$ is reduce mass of this system.

↳ Solution of Schrodinger equation for R(I)

$$\psi_1 = A e^{ik_1 x} + B e^{-ik_1 x}$$

$A e^{ik_1 x}$ ↓ Incident; $B e^{-ik_1 x}$ ↓ reflected part

and

$$k_1 = \sqrt{2mE} / \hbar$$

↳ Solution of S. Eqtn for R(III)

$$\psi_3 = C e^{ik_1 x}$$ here only forward portion is involved

↳ A, B and C to be evaluated (Find) later.

↳ For region (II)

$$\frac{d^2\psi}{dx^2} + \frac{2m}{\hbar^2}(E - V_0)\psi = 0$$

its Solution will be:

$$\psi_{II} = Fe^{-K_2 x} + Ge^{K_2 x}$$

$Fe^{-K_2 x}$ ↓ reflected part; $Ge^{K_2 x}$ ↓ refracted part

↳ F & G are evaluated later:

where

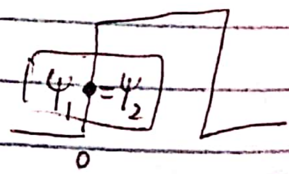
$$K_2 = \sqrt{\frac{2m(V-E)}{\hbar}}$$

$$K_2 = \frac{\sqrt{2m(V-E)}}{\hbar}$$

To evaluate A, B, C and F, G Following conditions are applied

Cond: No# (1) $\psi_1 = \psi_2$ at $x=0$

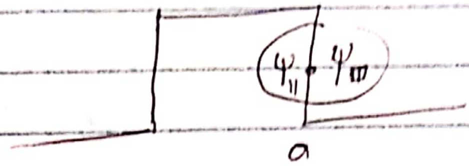
i.e



~~Cond No# (2)~~ So

$$\frac{d\psi_1}{dx} = \frac{d\psi_{II}}{dx} \text{ at } x=0$$

Cond: No# ②, $\psi_{II} = \psi_{III}$ at $x = a$



So

$$\frac{d\psi_{II}}{dx} = \frac{d\psi_{III}}{dx} \quad \text{at } x=a$$

apply 1st cond: on $\psi_1 = A^{ik_1x} + B^{-ik_1x}$

$$\boxed{\psi = A + B}$$

and also apply on (ψ_{II})

$$\psi_{II} = Fe^{-k_2x} + Ge^{k_2x}$$

so

$$\psi_{II} = F + G$$

or

$$\psi_{II} = -k_2 (F - G)$$

So

$$\psi_1 = A + B \Rightarrow ik_1 (A - B)$$

and

$$\psi_2 = F + G \Rightarrow -k_2 (F - G)$$

as $\psi_1 = \psi_{II}$ **A**

so

$$A + B = F + G$$

$$ik_1 (A - B) = -k_2 (F - G)$$

On proceeding calcution
we get: last result

$$\log_e(\lambda) = \log_e\left(\frac{v}{2r_0}\right) + \log_e\left[2.97\,(Z-2)^{1/2} \cdot r_0^{1/2} - 3.95\,(Z-2)\,E^{-1/2}\right]$$

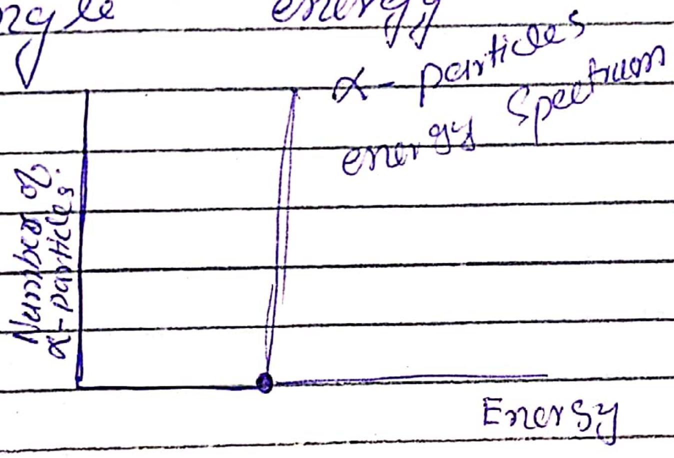
(⊖A) classically it is Said that particle having Energy greater than 25MeV entre to nucleous and also those particle can go out from nucleous who posses Energy greater then 25MeV while quantum Mechanics States that the Particle extract from nucleous very Slowly i.e at 4MeV 5MeV 11MeV

(*) This Topic is not very Important for paper

Tuneling meaning:
when a particle is enclosed in a box, So the particle repeatedly Strike with the walls and Search a whole Finally it get out at that Small whole ---- Tunneling

26/1/2022

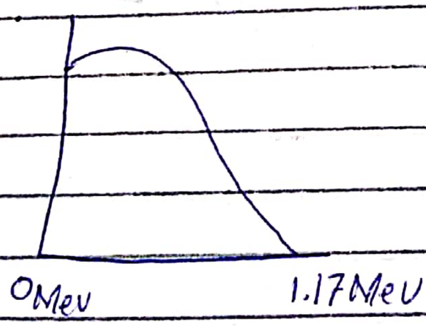
Spectrum of alpha particles have ~~the~~ is line Spectrum. i.e we have α-particles of single energy



Spectrum of β-particles is contineous Spectrum:

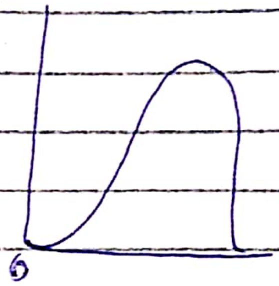
Graphs:

(1)

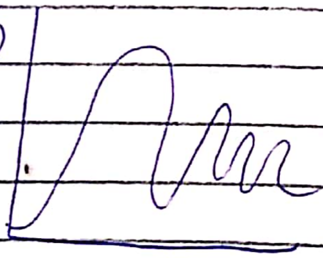


abundance → دستیاب

(ii)



(iii)



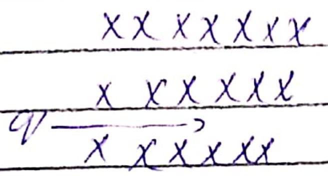
Syllabus TOPic (new)

Magnetic Lenz Spectrometer:-

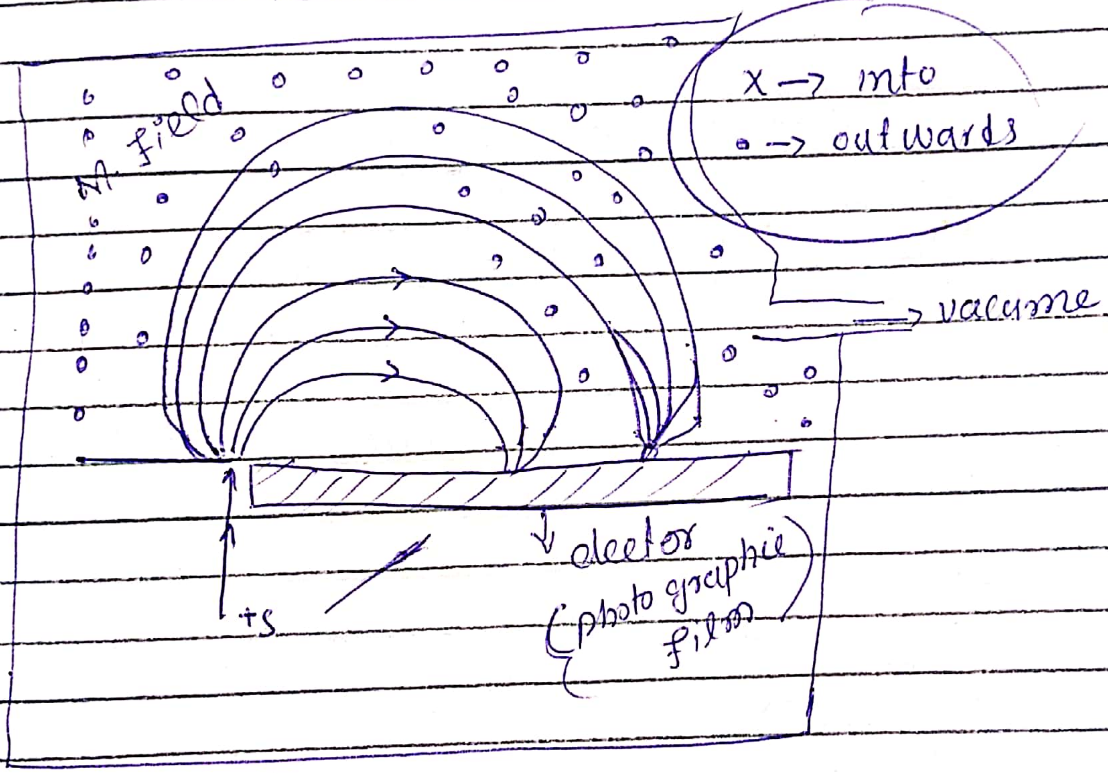
Spectro meter:

Spectrometer used For
(i) Separation of isotopes
(ii) Find masses of isotopes
(iii) Finding abundance of isotopes.

↳ when a charge particle move inside M-netic field. So the Force circulate that particle in circle as show



$F = q(v \times B)$



(*) here we only take +ve β particle for simplicity

If magnetic force acts as centripetal force and moves in circle then

$F_m = F_c$

$q(v \times B) = mv^2/r$

here $\theta = 90^\circ$

here β particle (mean electron so $q = e$)

So

$$qvB = mv^2/r$$

$$evB = mv^2/r$$

$$eB = mv/r$$

~~α~~ $r = mv/eB$

$r \propto m$ radius ~~inversely~~ directly related to mass

its mean radius of different particles are different

as

$$eBr = mv$$

$P = eBr$ Momentum of electron

↳ Relativistic energy and relativistic momentum of particle is

$$E^2 = p^2c^2 + m_0^2c^4$$

↳ $E = m_0c^2$ {is rest mass energy of particle at rest

(*)

relation b/w rest mass and relativistic mass m_0 is

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$$

$\Rightarrow E = mc^2$ {during motion (or) relativistic Form

(or)

$$E^2 = p^2c^2 + m_0^2c^4$$

(*) Concept of K.E:

~

K.E of β- particles will be

be $E - m_0c^2$

$$K.E_\beta = \sqrt{p^2c^2 + m_0^2c^4} - m_0c^2$$

$$K.E_\beta = \sqrt{e^2B^2r^2c^2 + m_0^2c^4} - m_0^2c$$

14/2/2022

see this lecture on 142 page Ghoshal

Theory OF Beta decay (or Isobaric transformation b/c A → remains unchanged)

β-disintegration energy

Neutrino Hypothesis:

↳ -ve β- particle decay $^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}X + {}^{0}_{-1}\beta + \bar{\nu} + Q$

→ neutron ⟶ proton + electron
so A remains unchanged.

↳ +ve β- particle decay

$$^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}X + {}^{0}_{+1}\beta + \nu + Q$$

→ proton ⟶ neutron + electron.

↳ Electron capture:

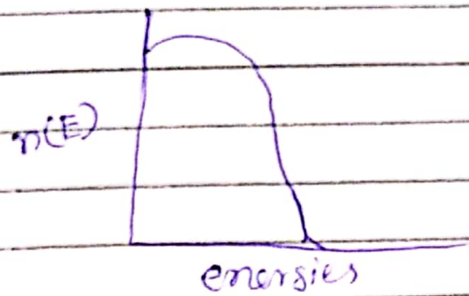
$$^{A}_{Z}X + {}^{0}_{-1}\beta \longrightarrow {}^{A}_{Z-1}X$$

when K shell electrons are captured by nucleus
so

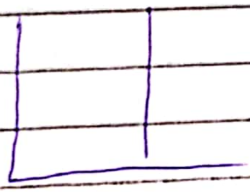
electron + Proton = ~~nucl~~ neutron
(already present in nucleus)

So Therefore Z decreases by 1 i.e Z-1

(*) β radiation Spectrum is contineous
i.e



α - radiation Spectrum is line Spectrum
i.e



(*) Neucleous doesnt posse electrons But when Neutron convert to proton So electron also produce
So Neutron also produce β - rays

(*) α - rays already present in nucleous

$\Rightarrow$ Q - (β disintegration Energy):

Q $\rightarrow$ always positive

$E = mc^2$

$$Q = \left[m_N \left({}^{A}_{Z}X \right) - m_N \left({}^{A}_{Z+1}X' \right) - m_e \right] c^2$$

(*) mass of neutrino is 200 times lighter than electron

→ For "Q" to be positive the mass of product nucleous must be ~~equal~~ Smaller than mass of parent nucleous

→ Lapton Faimly

members are
(i) electron (1/2)
(ii) neutrino (1/2)
These are Fermions
→ Follow Fermi Dirac Statistics.

→ neutron. mass:
nearly equal to zero
also charge equal to zero

i) C Cowan
ii) F Reines ↑

→ 1956 → descory of Neutrino
→ prediction gived by paully

1934 → hypothesis of Neutrinu by Fermi

Fermi hypothesis about neutrino:-
Fermi Said that nucleous don't contain es and β-particle But they prodece during β-decay).

→ α- decay only in heavy nucleous

→ β- decay occur's in every nucleous
let Z=1 i.e
proton ⟶ neutron + $\overset{+}{\text{electron}}$

→ 10^{14} neutron/s pass from human body

(*) when energy is +ive mean it is absorbed vice versa ⟶ −ive

neutron Made From quark i.e





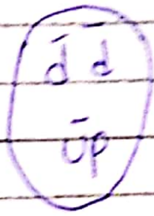
1up + 2 dawn $= 0$

$up = \frac{2}{3}e$

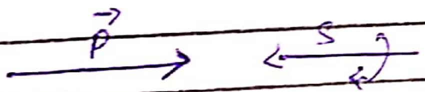
$d = -\frac{1}{3}e$

anti neutron

$1\bar{up} + 2\bar{d}$ $= 0$

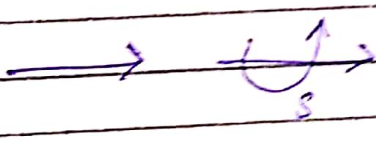


For Neutrino made From



momentum vector — spin vector

anti neutrino



16/2/2022

Theory of Gamma Decay (γ):

→ γ-rays is actually energy Paket

→ radiation having limit $\lambda \sim 10^{-12} \rightarrow 10^{-13} m$ known as γ-rays ($E = hf$)

(*) In atom electron and nucleus can be exited.

From de-exition of electron we can get

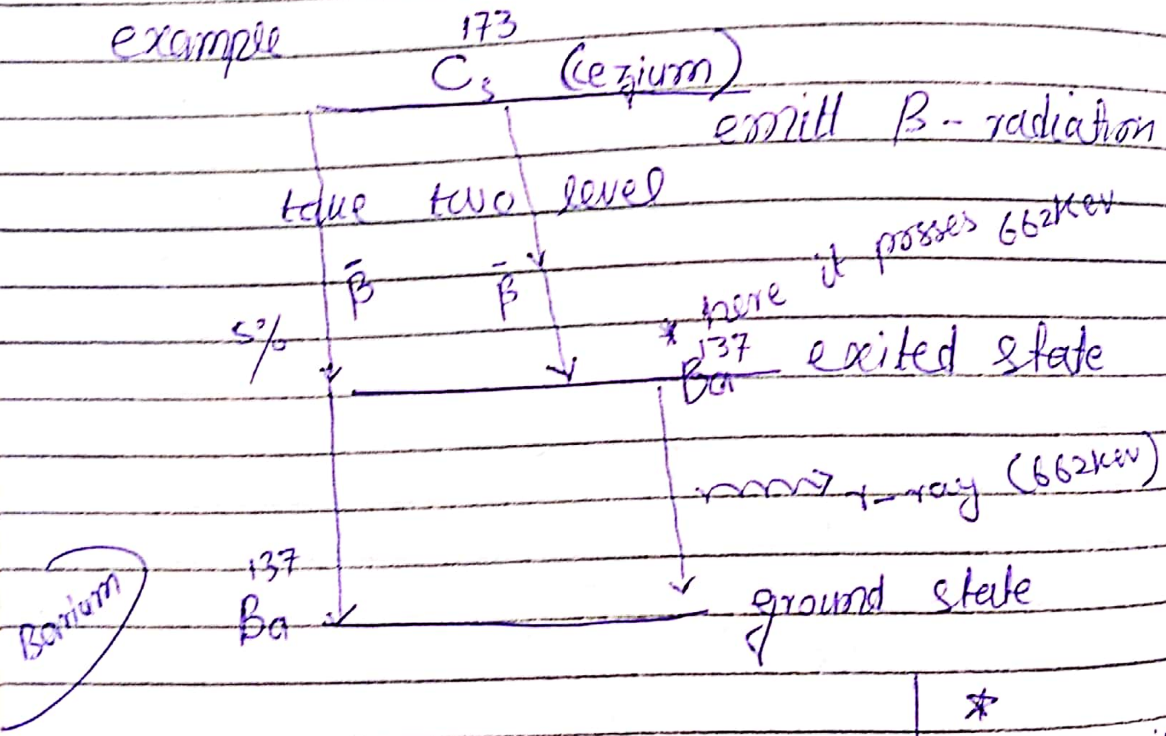
→ ultra violet radiation

→ x-ray photon

*) Frequency of γ-ray is so much greater, so its energy is also very high
i.e $E = hf$

So this high ray photon only get from nucleous exitation & de exition

example



*137
Ba mean exited

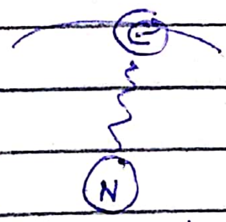
*
by β emittion
A → same
Z - change

(*) when γ-rays emitti so no change occure in A and Z only nucleous change from exited state to de-exited state.

→ posses no charg and mass move undeflected from E.F & M.F

γ- decay
- (i) Gama decay
- (ii) Internal conversion
- (iii) Internal pair conversion

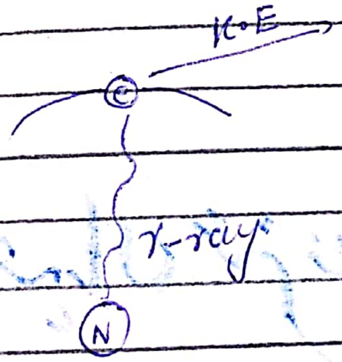
(ii) Nuclear de-exited but we don't get emitted radiation as γ-ray but this energy use for the removal of an electron (aguse effect)



exited

and this electron is called conversion electron.

⇒

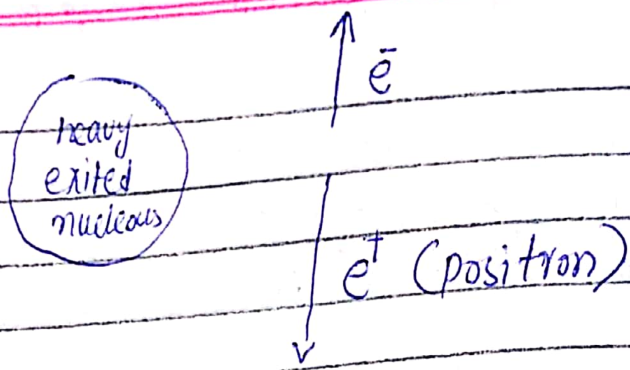


When γ-rays emitt so this energy use for two purpose
- (i) removal of electron
- (ii) K.E of electron.

E_γ = B.E of electron + K.E of e's

$E_e = E_\gamma - BE_e$

rest mass E of Electron and positron = 0.5 MeV



this is pair conversion

probability of internal pair conversion is largest at distance $\left(\frac{Z}{137}\right)^2$ times of "r_k"

Write theory for above topic:

"جہاں عزت، سچائی، خلوص
نظر آئے وہاں دوستی کا ہاتھ
بڑھاؤ ورنہ تمہاری تنہائی
تمہاری بہترین ساتھی ہے"

γ-ray photon → half integer
→ Faimly is bozon

Nuclear Isomerism:

The exited state of the nucleous where nucleous stays for a relatevely larger period is called isomerism.

⇒ Exited nuclei which are temporarily stable → nuclear isomer.

(*) A Normal nucleous de-exitation time is 10^{-12} sec. {emitts γ-rays photon}

(*) When the nucleous take 10^{-9} sec for dexitation so it will emitt γ-rays photon and this nucleous is called isomer ~~radiation~~

(or) when a nucleous stays for a relatively large period and becom de-exited by γ-emission so this radiation is known as isomeric transion

X^* : Simple exite

X^m metastable exite

(*) an nucleous can stay for long years in exited state.
i.e

→ $^{180m}_{73}Ta$ → 10^{15} year
↘ its spin is 9

→ $^{210m}_{83}Bi$ (Bismat) ~~log~~ 2×10^{19} year long lived is~~otope~~omer

→ $^{242m}_{95}Am$

→ First isomer:
$^{234m}_{91}Pa$ by Otto Hann in 1921

Q why Nucleous stay at exited state for longer time?

⇒ Reason → Forbiden de-exitation which occur due to occurence of greater spin change.

example

$^{180m}_{73}Ta \xrightarrow{\text{dexited}} {}^{180}_{73}Ta$ here Spin is 1

(180m → 9 spin)

So change of Spin $(9-1) = 8$ which is greater change So nucleous remain at exited state.

* ∽ * ∽ * ∽ *

Next Section

18/2/2022

NUCLEAR REACTION

Definition: The bombardment of different perticles (charged or neutral) on nucleous which may change the Size or properties of target nucleous, this is known as N R

→ First Nuclear Reaction (1919) by Rutherford

$${}^{4}_{2}He + {}^{14}_{7}N \rightarrow {}^{17}_{8}O + {}^{1}_{1}H \text{ (proton)}$$

natural Rxn ← (reaction)

He ↓ (Projectile)

H ↓ at this stage proton discover.

K.E of He^4_2 (or) α-particles are very low
i.e 10 MeV

For greater K.E of projectile
cyclotron was used
or particle accelerator

→ In 1932 First (particle accelerator) Nuclear reaction First time.
by ↓ Walton ~~and~~ and Cockroft

$$^1_1H + ^7_3Li \longrightarrow ^4_2He + ^4_2He$$

8 = 8
4 = 4
charged ↓ conserved

Gernally for Nuclear Rxn

$$a + X \longrightarrow Y + b$$

- a ↓ projectile
- X ↓ target nucleus
- Y ↑ ~~change or new nucleous~~
- b ↓ emitted by or extra product

→ $X(a, b)Y$

- X: target
- a ↓ projectile

$${}^{4}_{2}He + {}^{9}_{4}Be \longrightarrow {}^{12}_{6}C + {}^{1}_{0}n$$

$${}^{9}_{4}Be\,(\alpha, n)\,{}^{12}_{6}C$$

Types OF Nucleur Reactions:

(A) Reactions based on reaction Mechanism

(B) Reactions based on mass of projectiole i.e neutron or Helium etc used as projectile

(i) Elastic Scattering

here Momentum and K.E conserved

(ii) Inelastic Scattering:

(iii) Radiative Capture:

here nucleous capture some thing and then radiate it.

$${}^{1}_{1}H + {}^{27}_{13}Al \longrightarrow {}^{28}_{14}Si^{*} \longrightarrow {}^{28}_{14}Si + \gamma$$

(γ) emitts photon.

(iv) Compound nuclear Reaction:

~~here~~ it is Same with ~~or~~ radiative capture But here it emits particles not photons.

$$^{4}_{2}He + ^{27}_{13}Al \rightarrow ^{31}_{15}P \rightarrow ^{30}_{15}P + ^{1}_{0}n$$

(v) photo-disintegration:

$$^{2}_{1}H + ^{0}_{0}\gamma \rightarrow ^{1}_{1}H + ^{1}_{0}n$$

(6) Radio activity decay

(7) Fission reaction

(8) Fussion reaction.

⇒ For Type (B)

(i) Mass 1 ⇒ Means using one mass projectile i.e electron, proton nutron etc.

(i) proton induced

(P, α), (P, γ), (P, n)

(Rxtn types)

(ii) Neutron induced

(n, γ), (n, P), (n, α)

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$\binom{P\,2}{1N}$ → Dytron
↓
Nucleous having 2P and 1N

Mass "2" Rxtn:

(a) Deutron induced reaction

(i) (d, P)   (ii) (d, n), (iii) (d t)

Mass "3" Rxtn:

(Last PORTION)

Date: 9/3/2022
Assisment
Time: 11:26pm

Sources of Neutron:

Neutrons are produced in ~~nuclear~~ nuclear reactions. So all neutron Sources are made by exploring various types of nuclear reaction done by high energetic charged ions or by high energy electromagnetic radiation.

→ Some time Special arrangement of the materials are required for producing copious nutron flux as in nuclear reaction.

(i) Radioactive (α, n) Sources:

(ii) photoneutron Source

(iii) Accelerated charged particle Source.

(i) Radioactive (α, n) Source:

Neutron were discovered in the reaction

$$^{9}Be(\alpha, n)^{12}C$$ | Be -> Berillym

This reaction is still using as a base For the Formation of neutron Sources.
-> This reaction is exothermic $(Q>0)$ i.e $Q = 5.6$ Mev
So depending on the energy of projected α particle producing the reaction.

-> The energy of neutron Spreed.
i.e For $E_\alpha = 5.30$ Me
energy of Forward neutron = 10.6 MeV
enrgy of backward neutron = 1.6 MeV
b/c
The beryllium posses longer thickness. the α particle loss pert of their energy in going through different Thickness of Be befor the production of Rxtn. as a result neutron of different energies are emitted.

(ii) Photoneutron Source:

These Source use the (γ, n) gama neutron reaction on different target here gernally used targets are

(i) deutron istope (ii) ^{9}Be isotope.

→ ~~this~~ here the reactions are endothermic i.e $Q < 0$

→ here the energy of projectile must be greater than threshold of target.

^{2}H thershold is 2.226 Mev, ^{9}Be = 1.66 Mev while for other target which have been used E alway greater than 6 Mev.

→ X-rays can also be used ~~Q~~ for photoneutron Reaction.

In this Rxtn energy of neutron emitted is given as

$$E_n = \frac{A-1}{A}\left[E_\gamma - Q - \frac{E_\gamma^2}{1862(A-1)}\right] + \delta\cos\theta$$

→ $\Delta E = 2\delta$

* ✓~ * ✓~ * ✓~ * ✓~ *

(iii) Accelerated charged particle Sources:

These Sources are responsible for the production of intense beams of mono-energetic ~ neutrons. here the projectile include protons, deutrons, tritons, α-particles and

Some heavier nuclei accelerated in cyclotron

other names : i) Cockroft-Walton generator
ii) a Van de Graaff generator.

Accelerator based neutron sources mostly use the (P,n) and (d,n) reaction on lighter elements.

→ (i) (P,n) always endoergic (Q < 0)
→ (ii) (d,n) usually exoergic (Q > 0)

(i) $^{3}H(P,n)^{3}He$ $Q = -0.764$

(ii) $^{2}H(d,n)^{3}He$ $Q = +3.269$

Neutron Detectors:-

Neutrons are electrically neutral. So they cannot produce ionization in matter through they pass. however they can eject proton, deutron and α-particles etc during nuclear Reactions. even when they give low energy. Fast neutron can also eject recoil nuclei by elastic collisions. These charged particle ejected by neutron produce ionization in matter through which they pass.

We can ~~convert~~ divide the methods of neutron dection into two groups.

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(i) For Slow neutrons
(ii) Fas neutrons:

(i) Slow Neutron detection through charged particle production in Nuclear Reaction.

The reaction commonly use For detection are

(n, α) reaction

$^{10}B\,(n,\alpha)\,^{7}Li$ $Q = 2.79$ MeV

$^{10}B\,(n,\alpha)\,^{7}Li^{*}$ $Q = 2.31$ MeV

$^{6}Li\,(n,\alpha)\,^{3}H$ $Q = 4.79$ MeV

End

Dedicated To,

My Parents and Teachers with Deepest gratitude whose Love, and prayers have always been a Source of Strength for me

Usman Ali Shah